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Post-PLUARG Evaluation of Great Lakes Water Quality Management Studies and Programs
Volume II

Great Lakes Basin Commission
Ann Arbor, MI

Prepared for

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FOREWORD

The United States Environmental Protection Agency was created because of increasing public and governmental concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment.

The Great Lakes National Program Office (GLNPO) of the U.S. EPA, was established in Region V, Chicago to provide a specific focus on the water quality concerns of the Great Lakes. GLNPO provides funding and personnel support to the International Joint Commission activities under the U.S.-Canada Great Lakes Water Quality Agreement.

Under the terms of the Agreement a series of studies were funded to examine the relationship between land use and water quality. The studies were conducted by the IJC Pollution from Land Use Activities Reference Group (PLUARG). In order to further build upon the accomplishments of the PLUARG effort, GLNPO contracted with the Great Lakes Basin Commission to prepare this report which describes the work which is continuing to address the problem of pollution from land.

We hope that the information and data contained herein will help planners and managers of pollution control agencies make better decisions for carrying forward their pollution control responsibilities.

Madonna F. McGrath
Director
Great Lakes National Program Office

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15. SUPPLEMENTARY NOTES This study is to provide information on a number of significant studies and programs of relevance to Great Lakes water quality problems.

16. ABSTRACT

This report presents the results of recent efforts by the Great Lakes Basin Commission staff to update and integrate the findings and recommendations of the International Joint Commission's Pollution for Land Use Activities Reference Group (PLUARG) with other related studies.

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POST-PLUARG EVALUATION OF GREAT LAKES WATER QUALITY MANAGEMENT STUDIES AND PROGRAMS

Volume II

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Prepared for the Great Lakes National Program Office, EPA, in partial fulfillment of U.S. Environmental Protection Agency Interagency Agreement No. AD-85-F-0-015-0 with the Great Lakes Basin Commission.

This report presents information based in part on the results to date of Great Lakes Water Quality Management studies. Because these studies are ongoing, the findings and conclusions in this report will need to be periodically updated to reflect progress that has been made. This report is intended to promote discussion and further coordination of Great Lakes planning efort.

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DISCLAIMER

This study was carried out by the Great Lakes Basin Commission staff in partial fulfillment of an Interagency Agreement with the Great Lakes National Program Office, U.S. Environmental Protection Agency (EPA). The findings, conclusions and recommendations are those of the authors and do not necessarily reflect the views of U.S. EPA or the Great Lakes Basin Commission.

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EXECUTIVE SUMMARY

This report presents the results of recent efforts by the Great Lakes Basin Commission staff to update and integrate the findings and recommendations of the International Joint Commission's Pollution from Land Use Activities Reference Group (PLUARG) with other related studies. It is one of a series of U.S. Post-PLUARG activities recommended by the Reference Group to ensure that the initiatives begun under PLUARG are not lost.

The report concentrates on five different areas:

1. update of major water quality studies and resource planning and management programs and projects related to Great Lakes water quality concerns;
2. update on U.S. Great Lakes tributary loadings;
3. results of a Post-PLUARG meeting on pollution abatement strategies for the Great Lakes;
4. initial work developing "WATERSHED" - a management technique for choosing among point and nonpoint control strategies;
5. reconsideration of PLUARG findings and recommendations in light of new information.

Five appendices provide detailed information to support this report.

A number of national and regional programs are continuing to contribute to the development and implementation of nonpoint source controls in the basin. The Nationwide Urban Runoff Program, in particular, is expected to provide some much needed information on the benefits and effectiveness of urban controls.

Draft final recommendations of the Phosphorus Management Strategies Task Force generally confirm past recommendations made by PLUARG and the Great Lakes Basin Commission concerning point and nonpoint phosphorus control strategies for the lakes. The Task Force advocates a staged approach to phosphorus management, using the target loads established in the 1978 Great Lakes Water Quality Agreement as guidelines for planning purposes.

Some PLUARG recommendations for information needs still require attention, as identified by attendees at the recent Post-PLUARG meeting. These include the development of techniques and guidelines for identification of hydrologically active areas, the development of detailed cost information on agricultural nonpoint controls, and the identification of secondary effects associated with remedial measures to control phosphorous from nonpoint sources.

An examination of Great Lakes tributary data from water years 1975 to 1978 reveals substantial annual variations in both flow and load to the lakes. Natural variability in runoff was found to cause major variations in the loadings of total phosphorus and suspended solids. Data indicates that Lake Erie continues to receive the largest total phosphorus and soluble ortho phosphorus tributary loads.

CONCLUSIONS

NONPOINT SOURCE POLLUTION MANAGEMENT

1. Probably more progress has been made toward understanding nonpoint source pollution problems in the Great Lakes basin than any place else in the world. Results and recommendations from past and continuing programs in both the U.S. and Canada (i.e., PLUARG, 108(a) Demonstration Projects such as the Black Creek Study and the Washington County Project, the Wisconsin Fund, "208" Studies, the Lake Erie Wastewater Management Study, etc.) seem to be converging. However, with the completion of PLUARG, no formal mechanism remains for coordination and unified action.

2. The IJC's recommendation of regulation of manure spreading on frozen ground, as highlighted in its report to the governments on pollution from land runoff, does not reflect the work done on this subject in PLUARG.

3. There is still no indication that lead is causing water quality problems in the Great Lakes. The statement in the IJC's report to the governments that lead is a "pollution time bomb" is not in accord with the PLUARG report.

4. Draft final recommendations of the Phosphorus Management Strategies Task Force (PMSTF) generally confirm past recommendations of the Great Lakes Basin Commission concerning nonpoint source phosphorus control strategies for the Great Lakes.

5. Additional promotion and consideration should be given to the other benefits of nonpoint source controls (besides phosphorus load reductions) such as energy savings and reductions in heavy metal loadings. Negative secondary effects that may occur as a result of remedial programs should also be considered in development of a Great Lakes management strategy.

6. Acceptance of conservation tillage is rapidly increasing in many parts of the U.S. and Canadian basins. This is largely due to the energy savings realized with conservation tillage and the effort which has been made to demonstrate the utility of the method to farmers. The importance of a long-term, person-to-person technology transfer program should not be underestimated.

7. The economics of conservation tillage appear favorable following a year of observation on the Honey Creek Watershed project. Erosion reduction associated with no-till appears significant.

8. Results of the Menomonee River Pilot Watershed Study indicate that because soils eroding to waterways do not completely disperse during the early stages of transport, nonpoint source controls which trap soil particles of silt-size or larger and aggregates are able to capture a significant percentage of clays (and associated pollutants).

9. Results of the Menomonee River Pilot Watershed Study indicate that atmospheric inputs presently contribute more than 70 percent of the PCB load to Lake Michigan.

10. The Nationwide Urban Runoff Program will provide some much needed information on the benefits `and effectiveness of urban controls so that the necessity for controls beyond those recommended by PLUARG can be ascertained.

POINT SOURCE POLLUTION MANAGEMENT

1. Draft final recommendations of the PMSTF are in agreement with past recommendations made by PLUARG and the Great Lakes Basin Commission concerning point source phosphorus control strategies.

UPDATE ON POLLUTANT LOADINGS TO THE LAKE

1. Draft final recommendations of the PMSTF advocate a staged approach to phosphorous management, utilizing the target loads as guidelines for planning purposes. This approach recognizes the fact that phosphorous-induced water quality degradation is reversible, so that receiving waters are not irreversibly harmed if all pollutant inputs are not immediately controlled.

2. Recent information from the PMSTF confirms past estimates of the phosphorus load contributed to the lakes from various sources.

3. With regard to P availability, the majority of point source phosphorus which reaches the lakes appears to be in a biologically available form.

4. Based on an analysis of four years of data, natural variability in runoff was found to cause major variations in the tributary loading to the lakes of total phosphorus and suspended solids.

5. During water years 1975 and 1976 tributaries exhibited both high flows and loads for virtually all parameters relative to the historical average. In water year 1977 both flow and loading decreased markedly. Water year 1978 exhibited medium to high flows and loads, depending upon the lake basin.

6. An examination of data from water years 1975 to 1978 indicates that Lake Erie receives the largest total phosphorus and soluble ortho phosphorus tributary loads while Lake Superior receives the smallest loads.

7. As evidenced by examining data from water years 1976 and 1977, event response tributaries show much wider fluctuations in load with changes in flow then do stable response tributaries.

RECOMMENDATIONS

The following are offered as recommendations, in addition to the many implicit recommendations included in the "Conclusions".

1. Studies designed to provide detailed cost information on agricultural nonpoint controls should be stepped up.

2. Techniques and guidelines should be developed for identification of hydrologically active areas (remote sensing offers some promise).

3. The efforts of "208" agency programs and ongoing federal and state demonstration projects and programs should be coordinated to assure consistency in the recommendations made to the public concerning nonpoint source pollution control.

4. Studies should be encouraged on the percentage of pollutants contained in urban and rural runoff which are attributable to atmospheric deposition.

5. Funding should be provided for demonstration projects which assess the long-term effects of nonpoint controls.

6. Information from the large number of ongoing and completed agricultural research projects addressing conservation tillage systems in the basin (i.e. Maumee Basin Water Quality Demonstration Project, Honey Creek Watershed Project, Southeast Saginaw Bay ACP Project) should be used, if appropriate, to modify strategies for managing nonpoint inputs to the lakes.

7. Additional programs, like the Northeast Ohio Areawide Coordinating Agency's (NOACA) Lake Erie Tributaries Stormwater Effects Evaluation, should be encouraged to integrate Great Lakes water quality and fisheries management programs, thereby adopting an ecosystem approach.

8. The Soil Conservation Service Inventory of Prime and Unique Farmlands should be utilized in support of PLUARG's recommendation that farmlands which have the least natural limitations for agricultural use be retained for this purpose.

9. A tributary loading calculation program should be initiated using data from the last 20 years. This would give some indication of how tributary concentrations have changed over time, particularly following implementation of point source controls.

CHAPTER 1

INTRODUCTION

Under an Interagency Agreement with the U.S. Environmental Protection Agency (EPA), the Great Lakes Basin Commission (GLBC), in cooperation with the Great Lakes National Program Office (GLNPO) of EPA, has undertaken a number of activities to ensure that the findings and recommendations of PLUARG are considered and incorporated into ongoing water quality planning and management programs in the basin. The first Post-PLUARG report, entitled "Post-PLUARG Evaluation of Great Lakes Water Quality Management Studies," was completed in July of 1979 (Skimin *et al.*, 1979). A second report was completed in March, 1980 (Sullivan *et al.*, 1980). This report updates some of the work initiated under previous Agreements and provides information on recent activities.

Chapter 2 of this report provides information on a number of significant studies and programs of relevance to Great Lakes water quality problems. Results of PLUARG pilot watershed studies that have just become available are described. Recent developments from the U.S. Army Corps of Engineers' Lake Erie Wastewater Management Study (LEWMS) are discussed. Recent efforts under the Wisconsin Nonpoint Source Water Pollution Abatement Program (Wisconsin Fund) and the Corps of Engineers' Lorain Harbor Study are presented. Section 108(a) Demonstration Projects funded in the past few months are reviewed and summarized.

Updates on a number of nationwide programs currently addressing the problem of non-point source pollution either directly or indirectly are provided. Chapter 2 includes reviews of projects being conducted in the basin under the auspices of the Rural Clean Water Program, the Agricultural Conservation Program and the Nationwide Urban Runoff Program.

A description of the bibliography of 208 documents recently completed by the Basin Commission is included. The recent recommendations of the Phosphorus Management Strategies Task Force and the International Joint Commission are also reviewed.

Chapter 3 presents river mouth loadings calculated by Great Lakes Basin Commission staff for water years 1975 to 1978. A discussion of trends in river mouth loadings for total phosphorous, orthophosphorus, suspended solids and chloride is also included.

Chapter 4 summarizes the results of the Post-PLUARG meeting sponsored by the Basin Commission and the Great Lakes National Program Office last June. The meeting was held to assess technical developments which have occurred since the PLUARG study was completed in 1978.

Chapter 5 describes the management technique, "WATERSHED", currently being developed by Great Lakes Basin Commission staff for EPA. This management technique is designed to aid decision-makers in choosing among point and non-point source control strategies within a drainage basin.

CHAPTER 2

UPDATE ON WATER QUALITY STUDIES AND RESOURCE PLANNING AND MANAGEMENT PROGRAMS

The first two Post-PLUARG reports (Skimin et al., 1979; Sullivan et al., 1980) discussed a number of water quality studies and programs which are in the process of developing detailed information on the causes and control of nonpoint source pollution. This chapter updates information contained in the previous reports and describes other studies and programs which are addressing subjects relevant to PLUARG. Additionally, recent recommendations from the Phosphorus Management Strategies Task Force and the International Joint Commission are summarized and reviewed.

PILOT WATERSHED STUDIES

Menomonee River Pilot Watershed Study

Two draft final reports have been received from the Menomonee River Pilot Watershed Study since the last Post-PLUARG report (Sullivan et al., 1980) was completed. Additionally, a summary of the eight major research efforts of the Menoomonee Study, and recommendations for remedial measures was published in July of this year (Chesters et al., 1980).

A detailed study was made available in December, 1979, on the dispersibility of soils and elemental composition of soils, sediments, dust and dirt in the watershed (Dong et al., 1979). Measurement of the dispersibility of the major soil types in the basin was perceived to be an indirect method for evaluating nutrient availability and pollutants sorbed on the surface, as well as the potential of the soil to erode.

Dispersibility is one of the primary factors contributing to a soil's erosion potential. Soils which naturally disperse readily in water are of greater concern than those which remain in aggregate form since the dispersed fine particles are more readily transported overland in surface runoff. Finer-textured particles also remain in suspension longer, resulting in increased availability of the associated pollutants.

Results of the study indicated that soils eroding to waterways do not completely disperse during the early stages of transport. Thus, nonpoint source controls, such as settling ponds which are able to trap soil particles of silt-size or larger and aggregates, are able to capture a significant percentage of clays close to the source of the eroded material.

The particle-size distribution in samples of soils, bottom sediments, suspended sediments, and urban street dust and dirt was also analyzed. Sediment, dust and dirt samples with elemental compositions greater than soil levels were suspected of receiving inputs of pollutants. The locations of pollutant inputs to the river were identified by comparing the elemental composition of the clay-sized fraction of bottom sediments from different locations.

A two-part draft final report on the atmospheric chemistry of PCBs and PAHs and the significance of atmospheric inputs of these substances to Lake Michigan was made available in March, 1980 (Andren et al., 1980). Study results indicated that at the present time atmospheric inputs contribute over 70 percent of the PCB load to Lake Michigan.

Twelve polycyclic aromatic hydrocarbons were identified in aerosols sampled over Lake Michigan. This marked the first time measurements of this kind had been made over a large inland lake. Researchers felt that the PAHs identified originated from man-made combustion processes. Removal from the air was determined to be primarily a result of impaction. Thus, the air to water flux is slow, but significant, with the lake functioning as a permanent (or nearly so) sink. Adsorption and sedimentation eventually remove the PAHs from further cycling.

LAKE ERIE WASTEWATER MANAGEMENT STUDY (LEWMS)

Honey Creek Watershed Management Project

Among the primary components of the Honey Creek Project are the numerous farm plots demonstrating the use of reduced tillage and no-till methods of farming. Recently, the results obtained on these demonstration plots in 1979 were published (HCJBS, 1980). Plot histories from planting to harvest, economic data and soil erosion information were reported.

The economics of reduced and no-tillage systems appear favorable following a single year of observation. Twenty-eight of the 31 reduced-till and no-till plot variations for both soybean and corn cropping systems showed positive net returns. Although there were too few conventional tillage plots to allow for accurate comparisons, it was felt that reduced-till and no-till methods were at least as profitable as the conventional systems in the area.

Erosion reduction associated with no-till also appears significant. Fourteen of 19 plots with a variety of crop rotations had an estimated soil loss reduction of 50 percent or more. Seven of these showed reductions of 75 percent or more. The data suggests that on-site retention of nutrients would be increased as well.

Appendix A is a summary of information presented at a recent tour of the Honey Creek Watershed Management Project. An earlier tour of the project was described in "Post-PLUARG Evaluation of Great Lakes Water Quality Management Studies and Programs" (Sullivan et al., 1980). The environmental and economic impacts of conservation tillage practices in the Great Lakes basin is the subject of a recent Great Lakes Environmental Planning Study (GLEPS) contribution by GLBC staff (Baise et al., 1980).

SECTION 108(a) DEMONSTRATION PROJECTS

A number of projects have recently been funded with Section 108(a) monies by the U.S. Environmental Protection Agency. Descriptions of the studies concerned with nonpoint source pollution abatement follow.

Maumee Basin Water Quality Demonstration Project

The Maumee Basin Water Quality Demonstration Project is intended to show new and innovative techniques and programs for reducing agricultural sediment and rural sewage pollution within the Maumee River Basin. It is composed of two parts: the Allen County Project and the Defiance County Project.

Allen County Project. The Allen County Project is intended to run five years. It has received initial funding for 18 months.

The agricultural component of the project will focus on demonstration of voluntary conservation tillage systems. Specific objectives of this portion of the project are:

1. "To demonstrate that conservation tillage systems are a profitable and reliable alternative to conventional tillage systems on soil types which comprise a large portion of the Maumee Basin.
2. To demonstrate how to get farmers to readily adopt conservation tillage on a voluntary basis.
3. To demonstrate a program which could serve as a model for treatment of other critical areas within the Lake Erie Basin.
4. To demonstrate several types of alternative conservation tillage systems and to evaluate the degree of erosion protection afforded by each system. To demonstrate which

of these systems provide acceptable erosion control benefits and which provide preferred erosion control benefits.

5. To obtain information on the changes in insect and weed pressures and pesticide uses when there is a high concentration of conservation tillage in an individual area.

6. To obtain other technical and economic information which will aid existing water quality and technical assistance agencies in their current programs that address agricultural sediment reduction.

7. To bridge the gap between planning for reductions in agricultural sediment loadings and actually seeing it happen on the land." (ADSWCD, 1980)

The Allen County Project approach is similar to that of the Honey Creek Watershed Project under LEWMS. It is based on the premise that farmers will voluntarily adopt conservation tillage methods if they are demonstrated to be profitable (in terms of both production and energy savings) and reliable. Results from the Honey Creek Project continue to underscore the importance of a long-term, person-to-person technology transfer program. The Allen County Project will include group educational meetings, provision of equipment, agronomic management assistance (including pest management), and economic evaluations of the demonstration plots.

The monitoring project will address the extent to which conservation tillage practices are accepted. The degree of acceptance will subsequently be used to predict water quality changes, employing the relationship to be developed from monitoring efforts under the Defiance project. Parameters to be measured include: residue cover, percentage of land meeting the Universal Soil Loss Equation (USLE), and type of equipment owned by farmers.

The Allen County work effort will also include a rural sewage project to demonstrate alternatives for achieving water quality improvements in areas where a large number of failed individual sewage systems exist. Specific objectives are as follows:

1. "To monitor the existing conditions of the project area and quantify the existing effects on water quality.
2. To monitor the project area after replacement of the failed systems and quantify improvements in water quality.
3. To demonstrate administrative and procedural arrangements for bringing about replacement of the failed systems.
4. To serve as a model program which would be carried out in other problem areas within the Maumee Basin.
5. To evaluate the relative phosphorus and nitrogen contributions of agricultural run-off versus domestic sewage sources within the project area" (ADSWCD, 1980).

During the project's first year baseline data will be collected to determine existing water quality. Malfunctioning systems will also be identified. During the second year, failed systems will be corrected or replaced. Monitoring will continue for at least one year after the majority of this work is completed to document resultant changes in water quality.

Defiance County Project. The Defiance County Project is also scheduled to run for a five year period. Initial funding is for two years.

The Defiance project will compliment the Allen County study. The major difference is that financial incentives will be paid to farmers to obtain adoption of conservation tillage practices. The major objectives of the project are:

1. "To demonstrate and measure the effectiveness of Best Management Practices in reducing sediment loss from agricultural land.

2. To demonstrate the conservation value of several unique and innovative practices on the fine textured lake plain soils.

3. To monitor the effects of applied BMP's in reducing erosion and nutrient loss and to evaluate the suitability of the unique and innovative practices on crop production.

4. Design and carry out an effective information program to gain acceptance of the conservation program in the Defiance County Project and to use the results of the project to encourage implementation of BMP's in other areas of the county and the Great Lakes Basin.

5. To gain farmer acceptance of the BMP's and unique and innovative practices that are effective in reducing sediment loss and improving water quality" (ADSWCD, 1980).

The Defiance project will be intensively monitored to quantify reductions in sediment and improvements in water quality associated with implementation of BMPs. As previously mentioned, results of this monitoring effort will be extended for use in the Allen County program evaluation.

The different approaches encompassed in these two projects are expected to provide EPA with alternative strategies for carrying out future basinwide programs. It will be important that results of these two projects are viewed in conjunction with the findings of other ongoing and completed projects which have addressed the conservation tillage question (i.e., programs such as the Washington County, Wisconsin, Project; Honey Creek Watershed Project; and the Saginaw Bay ACP Project).

On-Site Innovative and Alternative Waste Disposal Project

At the time of this writing, EPA also anticipated funding a two year study by Purdue University and the Indiana State Board of Health on alternative on-site waste disposal systems. The project will install, monitor and evaluate a number of alternative and innovative demonstration systems on sites with different characteristics and soil types. Educational programs will also be conducted and publications developed during the course of the study to provide current information to health personnel, builders, engineers, homeowners, etc.

Both PLUARG and the IJC concluded that small scale, private waste disposal systems are not a major source of Great Lakes pollution, especially phosphorus pollution. However, failed systems can contribute to local water quality problems and present local health hazards in the basin.

Extension Agronomist - SE Saginaw Bay ACP Project

Section 108(a) monies have been provided to the Tuscola County Cooperative Extension Service to finance employment of an agronomist to work "one on one" with landowners involved in the Southeast Saginaw Bay ACP special project (see page 21). Funding is for a two year period. As previously mentioned, the importance of such a program has been underscored by results from the Honey Creek Watershed Project.

The agronomist will provide technical assistance to farmers interested in implementing conservation tillage practices. Since entirely new management is required with conservation tillage practices, the farm operator will need to be instructed in what equipment to use on various lands and types of soil as well as herbicides and insect problems and controls.

The extension agronomist will also conduct conservation tillage demonstrations on field size plots on different soil types to demonstrate various management practices and associated effects on production and soil loss. Nine to 20 demonstrations will be conducted each year. Data collected on each plot will serve as a basis for seminars, tours, and program evaluation.

Lake Erie Tributaries Stormwater Effects Evaluation

The Northeast Ohio Areawide Coordinating Agency (NOACA) has received 108(a) funds to conduct a one year study on the impacts of stormwater runoff on local fish communities. Previous work conducted by NOACA under the auspices of the "208" program produced evidence that local fish populations were strongly affected by channel scour and sediment transport, factors associated with runoff events (NOACA, 1979). By identifying and quantifying the impacts of stormwater runoff on aquatic communities, NOACA hopes to convince local authorities of the urgency and beneficiality of implementing nonpoint source control programs. This study provides a good example of how the integration of Great Lakes management programs, utilizing an ecosystem approach, may effectively address multiple concerns.

Great Lakes Basin Commission staff, at the request of the Great Lakes National Program Office, reviewed a number of these and other projects for 108(a) funding. Comments reflected the concerns expressed in PLUARG (1978), as well as recommendations of the Great Lakes Basin Commission (1979, 1980b).

LORAIN HARBOR STUDY

The Lorain Harbor and Black River are the focus of a U.S. Army Corps of Engineers study similar to the Cuyahoga River Restoration Study (see Sullivan et al., 1980). A reconnaissance report was completed in 1978 and subsequently revised in January of 1979 (U.S. Army COE, 1979).

Of particular interest is an erosion and sedimentation study which will be conducted on the Black River for the purposes of reducing annual maintenance dredging in the harbor and improving water quality. As presently contemplated, the study effort will concentrate on in-stream, as opposed to "upland" erosion. However, critically eroding upland areas will be identified using, in part, the LEWMS' Land Resource Information System (LRIS). Results will be presented to the appropriate levels of government and the implementation of preventive measures in these critical areas discussed. A preliminary feasibility report is scheduled for completion in March of 1982.

THE WISCONSIN NONPOINT SOURCE WATER POLLUTION ABATEMENT PROGRAM (WISCONSIN FUND)

Two of the four priority watersheds selected for inclusion in the 1980 Wisconsin Nonpoint Source Water Pollution Abatement Program are in the Lake Michigan drainage basin. One is the Green Lake watershed located in the Upper Fox River basin. Agricultural nonpoint source pollution is the principal concern to be addressed. It is estimated that over 85 percent of the phosphorus entering Green Lake is attributable to rural nonpoint sources (Baumann, 1980).

The second project area is the Onion River watershed, part of the Sheboygan River basin. Dairy farming is the principal land use, and manure carried in runoff from barnyards or frozen or saturated fields was identified as a serious nonpoint source pollution problem. Phosphorus loading to Lake Michigan is particularly great from this watershed due to the high clay content of the soil. Work plans for the two projects were not completed at the time of this writing.

STRATFORD/AVON RIVER ENVIRONMENTAL MANAGEMENT PROJECT

A two-year water quality management and demonstration project is underway in Ontario's Avon River basin. The Ontario Ministry of the Environment is providing $220,000 a year to identify and control pollutant inputs to the river. Demonstration efforts will focus on urban runoff and storm water quality improvements in the City of Stratford, as well as soil erosion and conservation measures in rural areas.

The first year of the study (1980/81) will concentrate on data collection, problem evaluation, and identification of remedial measures. Results of both the Honey Creek Watershed Management Project and the Black Creek 108(a) Demonstration Project are being evaluated for their applicability to this northern watershed. The overview model developed in PLUARG (Johnson _et al._, 1978; Heidtke _et al._, 1979) will be used to conduct a preliminary evaluation of changes in loadings associated with implementation of control measures.

THAMES RIVER BASIN IMPLEMENTATION PROGRAM

The Thames River Basin Implementation Program in Ontario is a three-year program which will both promote and evaluate the cost-effectiveness of rural best management practices for control of soil loss and improvement of water quality. Demonstration sites are currently being identified for good and poor management practices and existing or potential erosion situations. Site selection should be finalized by the fall of this year with planning and implementation of demonstration practices to follow.

In addition to the above, current municipal drain construction and maintenance practices will be evaluated and, if necessary, suitable demonstrations undertaken. A booklet of guidelines for minimizing environmental impacts associated with drain construction and maintenance will be developed for use by contractors, as well as individual farmers.

AGRICULTURAL CONSERVATION PROGRAM (ACP)

Southeast Saginaw Bay Control Drainage Basin Project

As discussed in the previous Post-PLUARG report (Sullivan et al., 1980), one of the largest special projects designated under the ACP is currently underway in the Saginaw Bay basin. At the start of the project's first year, $380,000 was used to cost-share various best management practices in the study area (ECMPDR, 1980). Additionally, a preliminary field survey of area farms is being conducted to collect data on operations using conventional and conservation tillage practices. A more detailed study of five to ten farms will be made to obtain additional data on the farming practices. A major portion of the economics model and computer program (see Sullivan et al., 1980) is also being developed. Evaluation of the BMPs is not scheduled to begin until October of this year.

RURAL CLEAN WATER PROGRAM

The Saline Valley Project

The Saline Valley Project has received $200,000 to launch its program of nonpoint source controls (see Sullivan et al., 1980). One of the first steps was the circulation of a newletter to rural landowners encouraging them to participate in the development of site-specific water quality management plans for their property. About 30 applications were received in the Washtenaw and Monroe County offices even before publication of the newsletter (Eacker, 1980). The program appears to be receiving favorable publicity via word of mouth.

The Great Lakes Basin Commission has supported the Saline Valley Project since its initiation. The Commission continues to provide input on project development through is membership on the Technical Assistance Subcommittee.

The Lower Manitowoc River Watershed Project

The Lower Manitowoc River Watershed Project, one of the five original Wisconsin Fund projects (see Sullivan et al., 1980) was recently selected for inclusion in the Rural Clean Water Program. Federal funds will be used to complete the project. As of June 1, 1980, $120,000 had been set aside for individual landowners to install best management practices.

NATIONWIDE URBAN RUNOFF PROGRAM

As discussed in previous Post-PLUARG reports, EPA has initiated a Nationwide Urban Runoff Program as part of the continuing Water Quality Management Program. The overall objectives of this program are to:

1. determine the extent to which designated water uses are being impaired by urban stormwater pollution,

2. develop water quality criteria appropriate for the protection of water uses from the transient and persistent effects of stormwater,
3. quantitatively determine the sources of urban stormwater pollutants,
4. evaluate the effectiveness of best management practices and,
5. develop strategies for the optimum wide scale implementation of BMPs (IEPA, 1978).

Ongoing Projects

There are six prototype projects under this program in Region V. Five are located within the basin. The sole exception is the Champaign, Illinois project.

In Champaign, Illinois, a pilot project to demonstrate the effectiveness of a streetsweeping program has been initiated. The project will extend over a three year period and will consist of study before, during and after implementation of BMPs. The overall objectives of the program are:

1. To demonstrate the effectiveness of streetsweeping as a BMP and to evaluate streetsweeping operations as affected by sweeping frequencies, land use, and other factors.
2. To determine the significance of deposition and scour in sewers during transport of pollutants to receiving waters. To determine the fraction of pollutant runoff from the street surface.
3. To determine the pollutant contribution attributable to atmospheric fallout and rainfall.

4. To obtain information to calibrate the continuous CONQUIL model. Information needs include determination of coefficients for the function relating total solids accumulation on street surfaces with time, land use, street surface type and condition, traffic count, and season, as well as determination of coefficients for the function relating rate of material washoff from paved surfaces to available materials, particle size, slope, flow rate, surface roughness, and traffic.

Michigan's Tri-County Regional Planning Commision (TCRPC) will be administering a second prototype project in the state's capitol. Three BMPs will be evaluated as components of a multi-million dollar urban storm drainage improvement project. The BMPs to be included are an in-line upsized tile with sumps below grade draining a residential area; an in-line surface "wet" retention basin draining a shopping center (with retained water used to irrigate an adjoining golf course); and an off-line "dry" detention basin located downstream of the "wet" retention basin.

Monitoring and analysis will occur over a three year period with the project scheduled for completion in the spring of 1982. The major objective of the study will be to determine the cost-effectiveness of the three BMPs. Capital costs, operation and maintenance costs, as well as long-term operational costs, will be determined. Loads of various pollutants in the stormwater entering and leaving each BMP will be obtained. An assessment will also be made of the impact of these practices on receiving water (Grand River) quality.

The Wisconsin Department of Natural Resources (WDNR) and the Southeastern Wisconsin Regional Planning Commission (SEWRPC) will be conducting a study in Milwaukee County, Wisconsin, to determine the water quality effects of streetsweeping timing and frequency in a public works program. The study will be conducted for three years with a final report anticipated by the summer of 1982.

A second objective of the project is to develop a methodology which municipalities can use to design urban nonpoint source control programs to meet water quality objectives. The Model Enhanced Unit Load (MEUL) model, developed during the Menomonee River Pilot Watershed Study, will be modified to allow managers to design control programs using readily available data such as land use, slope and imperviousness of soil.

Additional objectives include the determination of the contribution of pollutants from roof tops, atmospheric deposition, and winter accumulation to urban watersheds. The impact of a streetsweeping program on receiving water quality will also be evaluated.

Transferability of study results to areas outside Milwaukee County will be assessed. Results will be transferred using a simple model designed to use readily available information. The model will be tested for municipalities in the SEWRPC region.

One of the Southeast Michigan Council of Governments' (SEMCOG) Nationwide Urban Runoff Program projects will test the effectiveness of BMPs which were already installed and in use for control of excess runoff and sediment in Oakland County. Project objectives include the following:

1. To monitor the water quality of stormwater discharges leaving various retention systems and to determine the effect on receiving waters.
2. To analyze the effectiveness of alternative detention systems.
3. To analyze the effectiveness of existing institutional arrangements for establishing water quality control procedures and to formulate recommendations for necessary changes.
4. To develop guidelines for use in developing stormwater retention systems that optimize water quality.

5. To estimate costs for detention configurations and maintenance.

6. To determine operation and maintenance requirements for stormwater retention systems (SEMCOG, 1978).

The Southeast Michigan Council of Governments is administering a second NURP project in the Huron River watershed of Washtenaw County, Michigan. The project began in October of 1978 and is scheduled to terminate in May of 1981. Three categories of BMPs are being evaluated for their effectiveness and cost in reducing or preventing pollutant loading from urban runoff: (1) a runoff ordinance; (2) natural wetland, and (3) surface retention/detention.

A substantial amount of work has been completed on the effects of a man-made impoundment on downstream water quality. Preliminary evaluation indicates that the pond is successfully mitigating many of the deleterious effects of storm drain discharges to the river. For example, utilizing a mass balance approach, it was determined that large quantities of heavy metals and suspended solids discharged to the pond were retained within the pond area (ECTP, 1980). At the same time, however, the deposition of such materials creates the potential for long-term impacts on both the impoundment and downstream waters.

The Northeast Illinois Planning Commission (NIPC) is assessing the control potential of wet-bottom detention facilities. They are also studying the sources and movement of urban stormwater pollutants. The focus of their study is Lake Ellyn.

Data are currently being collected to characterize the sources of urban runoff pollutants, their spatial and temporal distribution in the watershed, and their transport mechanisms. The work effort includes atmospheric deposition sampling to provide information on the contribution of pollutants by rain and dry fallout. This is consistent with one of the major recommendations of the Post-PLUARG meeting that "studies should be encouraged on the percentage of pollutants contained in urban and rural runoff which are attributable to atmospheric deposition" (GLBC, 1980a).

Sampling of runoff water quality, flow and precipitation began in March of 1980. The quality and quantity of bottom materials in the basin is also being sampled. The removal efficiency of the detention basin will be evaluated over a range of events, as will pollutant characteristics and the ability of the basin to retain solids for two particle size intervals.

A summary of the work effort during the first project year was recently completed by NIPC for EPA. The paucity of data precluded the formation of any firm conclusions at the time of this writing.

SOIL AND WATER RESOURCES CONSERVATION ACT (RCA)

The U.S. Department of Agriculture's (USDA) draft Appraisal and Program Report (see Sullivan et al., 1980) drew over 67,000 written responses during the public review and comment period which ended March 28, 1980. The information received has been evaluated and a report prepared on the nature and substance of the public's comments. The RCA Coordinating Committee is now reviewing the contents of this report. This information, in conjunction with a Lou Harris-USDA public opinion poll on conservation, will be used to prepare the USDA's recommended soil and water conservation program.

The recommended program will then be presented to the Secretary of Agriculture and then to the public for review and comment. Upon completion of the public review period, the USDA will transmit the recommended program to the President who will then send it to the Congress.

SOIL CONSERVATION SERVICE PRIME AND UNIQUE FARMLANDS INVENTORY

The Soil Conservation Service (SCS) is publishing inventory maps delineating prime and unique farmland and farmland of state and local importance by county. State maps are also being prepared which show general areas of prime farmland. States select counties for the inventory based on need. A high priority is assigned to those counties experiencing rapid land use change. The maps will help officials, planners and the general public in their efforts to retain valuable farm acreage. This is consistent with PLUARG's recommendation that farmlands which have the least natural limitations for agricultural use be retained for this purpose (PLUARG, 1978).

The agency hopes to publish 1,200 county maps by mid-1980. Table 1 lists inventory maps of counties in the Great Lakes basin which were published as of January, 1980. An updated listing of county inventory maps will be available this fall.

TABLE 1

COMPLETED PRIME AND UNIQUE FARMLANDS COUNTY INVENTORY MAPS IN THE GREAT LAKES BASIN

MAPS PUBLISHED (COUNTY)	DATE	IN PROGRESS	EST. PUBLICATION
*** Illinois**		Will	April 1980
		McHenry	April 1980
DuPage	May 1979		
Kane	May 1979		
Lake	May 1979		
*** Indiana**			
Lake	February 1978		
Allen	September 1977		
Elkhart	January 1979		
Michigan			
Genesee	March 1977		
Ottawa	March 1977		
Grand Traverse	June 1977		
Macomb	September 1979		
Muskegon	October 1979		
Lapeer	November 1979		
St. Clair	December 1979		
Washtenaw	January 1979		
Minnesota			
Carlton	September 1979		
*** New York**			
Yates	January 1978		
Ontario	February 1978		
Monroe	November 1979		
Genesee	January 1980		
Niagara	January 1980		
Orleans	January 1980		
Seneca	January 1980		
Ohio			
Wood	January 1977		
Hancock	June 1977		
Pennsylvania			
Erie	March 1978		
Wisconsin			
Washington	May 1978		
Waukesha	September 1979		
Walworth	September 1979		
Brown	September 1979		
Kenosha	September 1979		
Ozaukee	September 1979		
Milwaukee	September 1979		
Racine	September 1979		

GREAT LAKES BASIN COMMISSION "208" REPORT BIBLIOGRAPHY

"208" water quality management agencies generated and compiled much valuable information as they responded to the mandates of the Federal Water Pollution Control Act (P.L. 92-500). In an effort to maximize the utilization of this information in other planning and management activities in the basin, a key-word coded bibliography of "208" water quality management planning reports has been completed by the Basin Commission staff. Information on the hundreds of reports developed by "208" agencies in the Great Lakes basin has been entered into the Basin Commission's computer. At the time of this writing, the bibliography contained 745 entries. The bibilography will be updated as additional reports become available.

Reports can be selectively retrieved by: (1) state, (2) lake, (3) river basin group, (4) agency, or (5) subject (key word). Multiple specification retrievals are also possible. A complete list of keywords is included in Table 2. Appendix B contains an example of a retrieval utilizing the keywords: "Remedial Measures," "Problems" and "Costs" under "Nonpoint Sources."

The bibliography is available for use by the general public, as well as by planning and management agencies. It may be accessed through the Great Lakes Information Center at the Great Lakes Basin Commission.

TABLE 2

208 BIBLIOGRAPHY
KEY WORD DICTIONARY

- 100 Point Sources
  - 110 Sources
  - 120 Projections
  - 130 Alternatives
  - 140 Recommendations
  - 150 Facility Plans
- 200 Nonpoint Sources
  - 210 Problems
  - 220 Remedial Measures
  - 230 Recommendations
  - 240 Unit Area Loads/Models
  - 250 Other
  - 260 Costs
- 300 Toxic Substances
  - 310 Problems
  - 320 Special Studies
  - 330 Management Programs
- 400 Atmospheric Loads
- 500 Great Lakes Issues
  - 510 CZM
  - 520 Great Lakes Water Quality
    - 521 Recommendations
- 600 Land Factors
  - 610 Inventory
  - 620 Projections
  - 630 Soils/Geology
- 700 Population
  - 710 Current
  - 720 Projected
- 800 Sludge
  - 810 Quantity
  - 820 Disposal Plan
  - 830 Alternatives/Techniques
- 900 River and Lake Basin
  - 910 Water Quality Assessments
  - 920 Detailed Studies
  - 930 Modeling Activities
  - 940 Wast Load Allocations
  - 950 Other
- 1000 Biological Studies
- 1100 Other Special Studies
  - 1110 Groundwater
  - 1120 Water Conservation
  - 1130 Phosphorus
  - 1140 Rainfall
  - 1150 Inland Lakes
  - 1160 Maps
- 1200 Wetlands
- 1300 Dredging
- 1400 Management Plan
  - 1410 Existing Framework
  - 1420 Alternatives
  - 1430 Recommendations
  - 1440 Objectives
  - 1450 Other
    - 1451 Economics
    - 1452 Implementation
    - 1453 Legislation/Legal Issues
    - 1454 Report Summaries
- 1500 Public Participation
- 1600 Work Program/5-yr Strategy
  - 1610 Annual Work Program
  - 1620 Five Year Strategy
- 1700 Other
  - 1710 Environmental Assessment

THE PHOSPHORUS MANAGEMENT STRATEGIES TASK FORCE RECOMMENDATIONS

The draft final report of the Phosphorus Management Strategies Task Force (PMSTF) was made available June 30, 1980. The document is now under review by the Great Lakes Science Advisory Board and the Water Quality Board of the IJC. The IJC's final recommendations on phosphorus management strategies for the Great Lakes should be available this fall.

The report, entitled "Phosphorus Management for the Great Lakes," includes a review of the 1978 Great Lakes Water Quality Agreement (GLWQA) phosphorus target loads, a discussion of phosphorus inputs to the lakes, an evaluation of the mathematical models used in establishing the target loads, a review of point and nonpoint source pollution controls, a recommendation for a staged approach to phosphorus management, and a discussion of information needs. In the draft final report, the PMSTF "proposes that a phosphorus management strategy be developed as a continuing process encompassing a staged approach which includes implementation programs, study programs, evaluation of studies, and decision making" (PMSTF, 1980). The task force's recommendations for the proposed strategy are summarized below.

Point Source Control

The task force recommends that municipal wastewater treatment plants in the basin which discharge in excess of 1 million gallons per day (mgd) limit the total phosphorus concentration in their effluents to a maximum of 1.0 mg/L. Plants which can achieve levels less than 1.0 mg/L should be encouraged to do so. This mirrors the Basin Commission's recommendation for phosphorus control at municipal plants (GLBC, 1979; GLBC, 1980b).

The task force recommends that planning for future municipal facilities in the lower Great Lakes should consider future requirements for phosphorus levels in the effluent on the order of 0.1 to 0.5 mg/L. It is further recommended that the phosphate detergent ban be retained and controls extended to the states of Pennsylvania and Ohio. This is consistent with the resolution adopted by the GLBC in November of 1976 which reads as follows:

> "The Great Lakes Basin Commission believes that the control of phosphorus in detergents is an effective action that can be taken to preserve the future quality of the Great Lakes. Therefore, it recommends that all appropriate governments require detergents manufactured or sold for domestic use in the Great Lakes Basin not contain phosphorus in excess of 0.5 percent by weight expressed as elemental phosphorus" (GLBC, 1976).

The effects of a detergent phosphorous ban on municipal wastewater treatment in the basin is the subject of a recent Great Lakes Environmental Planning Study report by GLBC staff (Heidtke et al., 1980a). Changes in average influent and effluent loadings of total phosphorous at municipal sewage treatment plants are examined, as well as the potential economic impact on chemical phosphorus removal programs.

The PMSTF reviewed a variety of treatment and management options available to reduce phosphorus in municipal wastewaters. The task force concluded that the most cost-effective option for a given municipality must be determined on a site-specific basis. Existing facilities, final effluent requirements, location, sludge disposal, and costs of chemicals should all be considered. It recommends that research and development efforts which focus on new or innovative technology be expanded.

Land application of wastewater is recommended where cost-effective. This is consistent with the Basin Commission's recommendation that water quality planning "give more consideration to alternatives to traditional waste treatment, such as land application" (GLBC, 1980b). A recent Great Lakes Environmental Planning Study contribution completed by GLBC staff investigated the advantages and disadvantages of land application of municipal wastewater in the basin (Heidtke et al., 1980b). The study also addressed the comparative costs of treatment by land application versus more conventional technologies.

Finally, the PMSTF recommends that studies be initiated to determine reductions in toxics and hazardous substances associated with phosphorus removal. This reflects a prior GLBC recommendation that water quality planning "evaluate the effectiveness of remedial programs on parameters besides those (they) are designed to affect" (GLBC, 1980b).

Nonpoint Source Control

The task force concluded that nonpoint source controls may be required to provide part of the additional load reductions projected for Lake Erie and Lake Ontario (3,700 tons/year and 2,600 tons/year, respectively [best estimates]). The PMSTF recognized that "nonpoint management plans are ... hampered by a lack of knowledge about the effectiveness of remedial measures in reducing loadings and the question of relative biological availability of phosphorus" (PMSTF, 1980). Until a thorough analysis of specific problem areas and alternative remedial measures is undertaken, the task force recommends that voluntary, low-cost remedial measures (Level 1) (PLUARG, 1978) be implemented, where appropriate, across the basin.

This is consistent with PLUARG's recommendations as well as the recommendation in the IJC's report to the governments, which states:

> "Governments (should) implement low cost but generally beneficial measures throughout the Basin ... at least PLUARG 'Level 1' rural and urban control measures..." (IJC, 1980).

It is also consistent with the GLBC's recommendation that "nonpoint source control programs should be immediately implemented, but should emphasize measures which can be implemented at relatively low cost" (GLBC, 1980b).

Consistent with the IJC's and PLUARG's recommendations, the task force stressed the need for identification of hydrologically active areas and concluded that implementation of remedial measures should proceed on a priority basis, treating areas where the largest and most rapid reductions can be achieved at the least cost. This also reflects recommendations made by the GLBC concerning phosphorus nonpoint source control (GLBC, 1980b). The need for development of techniques and guidelines for identification of hydrologically active areas was also a concern expressed by attendees at the recent Post-PLUARG meeting (See Appendix D). The PMSTF further recommends that a modeling capability be developed for predicting phosphorus reductions from critical areas.

The task force recommends initiation of demonstration watershed studies in critical problem areas to evaluate: (1) cost-effectiveness of remedial measures, (2) problems associated with implementation, and to (3) provide examples of programs as incentive for landowners. Their recommendation is, again, consistent with the Basin Commission's recommendations concerning phosphorus nonpoint source control strategies (GLBC, 1980b).

The PMSTF recommendation is supported by the following conclusions and recommendations expressed at the Post-PLUARG meeting:

1. "Little is known about the long-term effects of nonpoint controls. There is a need for adequately funded, long-term demonstration programs.

2. It is recommended that studies designed to provide detailed cost information on agricultural nonpoint controls be stepped up.

3. Additional consideration ... should be given to the other benefits of nonpoint source controls (besides phosphorus load reductions)... Negative secondary effects ... should also be considered" (GLBC, 1980a).

The task force recommends implementation of a basinwide public information and education program. This is consistent with PLUARG's recommendation "that greater emphasis be given to the development and implementation of information, education and technical assistance programs" (PLUARG, 1978). The importance of education programs involving components of demonstration and technical assistance was also recognized at the Post-PLUARG meeting. Attendees noted that the success of the conservation tillage program under the Honey Creek Watershed Project, for example, was largely attributable to the effort which has been made to demonstrate the utility of the method to farmers (GLBC, 1980a).

The PMSTF also recognized the need for monitoring load reductions associated with control programs. This was recommended at the Post-PLUARG meeting:

> "Continued monitoring is necessary to establish whether the load reductions (including available phosphorus) expected from different remedial programs actually occur" (GLBC, 1980a).

Information Needs

Finally, the draft final report contains a recommendation that a permanent research organization be established to serve the phosphorus management needs of the lakes. Specifically, the organization would be charged with reducing uncertainties regarding the following:

1. Target loads
2. Phosphorus availability
3. Social benefits and costs associated with improving Great Lakes water quality.
4. Appropriateness of institutional approaches.
5. The structure of analytical models and development of data bases to facilitate attainment of the objectives.

The Basin Commission has also recommended that a study of benefits and costs of improving Great Lakes water quality be initiated (GLBC, 1980b).

THE INTERNATIONAL JOINT COMMISSION'S RECOMMENDATIONS

The IJC's report to the governments of Canada and the United States on pollution from land use activities in the basin was made available in March of 1980 (IJC, 1980). The Commission concluded that the boundary waters of the Great Lakes system are being polluted by land drainage. The IJC agreed with PLUARG's finding that such pollution occurs most seriously from land areas of intensive agricultural and urban use.

The IJC has formulated a series of 18 recommendations to the governments of the U.S. and Canada. The recommendations generally reflect those of PLUARG (PLUARG, 1978) as well as the GLBC's recommendations concerning water quality management (GLBC, 1980b) and the hazardous materials strategy for the basin (GLBC, 1980c) included in the Great Lakes Basin Plan.

However, in contrast to PLUARG's recommendations, the IJC has recommended that the governments adopt regulations to prohibit winter spreading of manure on frozen ground. Attendees at the recent Post-PLUARG meeting questioned the need for regulation of winter-spreading of manure on a basinwide basis (see Appendix D). Instead, for any given situation, an appropriate mix of controls should be developed which may or may not include elimination of winter-spreading of manure. Attendees felt that government funding of manure storage should not be encouraged because storage is commonly installed for the convenience of the farm operator and, therefore, should remain part of his cost of operation (GLBC, 1980a).

CHAPTER 3

UPDATE ON U.S. GREAT LAKES TRIBUTARY LOADINGS

As part of the PLUARG study, the Great Lakes Basin Commission, under contract with the Environmental Protection Agency (Contract No. 68-01-1598), produced a report entitled "United States Great Lakes Tributary Loadings" (Sonzogni et al., 1978). Annual loads to the Great Lakes from U.S. tributaries were estimated for eight parameters for water years 1975 and 1976 where data were available.

Because the 1975 and 1976 water years represented very high-flow conditions, it was desirable to calculate loads for water year 1977 which represented a very low-flow year. This chapter presents the results and conclusions of these calculations. Water year 1978 has also been included to provide another reference for illustrating the tributary loading process.

This update provides a perspective on the 1976 water year which was frequently termed the"base" year throughout the PLUARG process. It also allows for further analysis of the relationships among the point and nonpoint sources that contribute to tributary loadings.

METHODOLOGY

Loadings have been calculated for total phosphorus, soluble ortho phosphorus, suspended solids and chloride. These parameters were selected because of data availability and their importance in understanding the eutrophication process. Data were obtained for water years 1977 and 1978 for all lakes except Lake Erie. The Lake Erie calculations were completed for 1976, for which data were not available during the PLUARG study, and water year 1977. Because of the excellent work being done by the U.S. Army Corps of Engineers and the Heidleberg College Water Quality Laboratory on Lake Erie, it was decided to rely on their analysis rather than to recalculate loads for the lake. This information was not yet available at the time of this writing.

River mouth loads were calculated using the ratio estimator method as described in IJC (1976). This method has been widely reviewed and is generally accepted by the Great Lakes research and surveillance community as both the preferred and PLUARG standard method for calculating tributary loads. The method calculates an average daily load at the river mouth and adjusts for flow variability over an annual cycle. The adjusted daily load is then used to calculate an annual river mouth load.

Point source loading data were updated using "208" reports. All available point source information for present and future conditions were examined to provide data on the parameters of interest for all U.S. Great Lakes tributaries. Where "208" information was not available, the previously used data base compiled from state records was used. The method of calculating both point and diffuse river mouth loads and the methods used for calculating loadings from unmonitored areas are presented in Sonzogni *et al.*,(1978).

RESULTS

Tables 3, 4, 5 and 6 present tributary and land runoff loading information for the entire U.S. Great Lakes basin. Table 3 gives information by lake and the total U.S. Great Lakes basin for water years 1977 and 1978. Table 4 provides information on individual hydrologic areas within river basin groups[1]. Table 5 presents the 1976 values for Lake Erie that were not available when the PLUARG tributary loading report (Sonzogni *et al.*, 1978) was published. Table 6 shows the hydrologic area breakdown of these loads. All values presented in these tables are based upon an analysis of point and nonpoint inputs to individual rivers draining the U.S. portion of the basin. The values for the hydrologic areas have been rounded to two significant figures. The river basin group totals, lake totals, and U.S. basin totals are summations of their respective hydrologic area values.

[1] A description of the U.S. tributaries, their organization and maps of their drainage basins may be found in Hall *et al.*, (1976).

Table 3

U.S. GREAT LAKES

TRIBUTARY LOADINGS
WY 1977, WY 1978

LAKE		Chloride 1977				Chloride 1978			
NUMBER	NAME	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
1	Lake Superior	80,220	31,400	51	9.4	104,060	35,710	62	15
2	Lake Michigan	490,200	405,080	60	25	590,300	454,300	67	34
3	Lake Huron	200,600	181,910	33	16	263,800	228,690	52	32
4	Lake Erie*	592,200	494,000	76	81	NA	NA	NA	NA
5	Lake Ontario	1,166,000	1,122,900	52	130	1,489,200	1,434,900	59	190
	TOTAL*	2,529,220	2,235,290	58	48	---	---	---	---

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

* 1978 Lake Erie data not available (NA)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 3

U.S. GREAT LAKES

TRIBUTARY LOADINGS
WY 1977, WY 1978

LAKE		Total Phosphorus 1977				Total Phosphorus 1978			
NUMBER	NAME	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
1	Lake Superior	780	374	83	.15	1,343	600	94	.29
2	Lake Michigan	2,173	1,768	46	.09	3,178	2,499	62	.17
3	Lake Huron	791	653	42	.08	972	758	53	.12
4	Lake Erie	5,130	4,018	57	.53	NA	NA	NA	NA
5	Lake Ontario	1,800	1,390	50	.20	1,993	1,640	56	.24
	TOTAL	10,674	8,203	55	.19	---	---	---	---
LAKE		Soluble Ortho Phosphorus 1977				Soluble Ortho Phosphorus 1978			
1	Lake Superior	139	63	71	.022	152	54	72	.025
2	Lake Michigan	819	587	38	.026	1,191	774	55	.056
3	Lake Huron	369	308	39	.034	367	265	28	.024
4	Lake Erie*	1,334	1,054	24	.058	NA	NA	NA	NA
5	Lake Ontario	704	605	41	.063	552	476	20	.025
	TOTAL*	3,365	2,621	35	.038	---	---	---	----
LAKE		Suspended Solids 1977				Suspended Solids 1978			
1	Lake Superior	594,800	399,880	97	130	706,400	395,800	100	160
2	Lake Michigan	341,210	272,290	90	26	677,400	519,000	94	54
3	Lake Huron	262,800	190,500	95	60	364,700	260,200	95	82
4	Lake Erie*	2,958,300	2,253,800	99	520	NA	NA	NA	NA
5	Lake Ontario	1,331,600	1,130,500	99	290	881,700	710,800	97	190
	TOTAL	5,488,710	4,246,970	98	180	----	----	----	----

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

*1978 Lake Erie data not available (NA)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE SUPERIOR

WY 1977, WY 1978

Hydrologic Area		Total Phosphorus 1977				Total Phosphorus 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
1.1.1	Superior Slope Complex	110	0	100	.18	170	0	100	.29
1.1.2	Saint Louis River	70	70	76	.06	310	310	95	.31
1.1.3	Apostle Island Complex	140	47	66	.27	280	97	100	.55
1.1.4	Bad River	88	0	98	.34	140	0	99	.55
1.1.5	Montreal River Complex	41	35	77	.41	15	14	36	.07
	River Basin Group 1.1 Total	449	152	83	.16	915	421	98	.37
1.2.1	Porcupine Mountains Complex	20	6	87	.06	22	6	88	.07
1.2.2	Ontonagon River	140	140	99	.40	120	120	99	.33
1.2.3	Keweenaw Peninsula Complex	21	0	100	.06	86	0	100	.25
1.2.4	Sturgeon River	37	37	100	.20	29	29	100	.16
1.2.5	Huron Mountain Complex	54	0	14	.03	58	0	15	.03
1.2.6	Grand Marais Complex	19	18	94	.06	70	0	98	.22
1.2.7	Tahquamenon River	21	21	86	.08	24	24	88	.10
1.2.8	Sault Complex	19	0	100	.27	19	0	100	.27
	River Basin Group 1.2 Total	331	223	84	.14	428	179	87	.18

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[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE MICHIGAN
WY 1977, WY 1978

Hydrologic Area		Total Phosphorus 1977				Total Phosphorus 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
2.1.1	Menominee Complex	17	8	100	.06	24	11	100	.09
2.1.2	Menominee River	51	51	15	.01	100	100	58	.06
2.1.3	Peshtigo River	21	21	0	---	27	27	3	.01
2.1.4	Oconto River	46	46	94	.17	42	42	94	.15
2.1.5	Suamico Complex	5	2	100	.04	15	5	100	.12
2.1.6	Fox River	360	360	57	.12	780	780	81	.37
2.1.7	Green Bay Complex	130	75	76	.15	390	210	92	.58
	River Basin Group 2.1 Total	630	563	60	.09	1,378	1,175	82	.26
2.2.1	Chicago-Milwaukee Complex	260	56	28	.13	480	150	60	.51
2.3.1	Saint Joseph River	300	300	33	.08	300	300	31	.08
2.3.2	Black River (S.Haven) Complex	16	0	62	.11	13	0	54	.08
2.3.3	Kalamazoo River	170	170	0	---	200	200	10	.04
2.3.4	Black River (Ottawa Co.) Comp.	14	0	51	.11	12	0	43	.07
2.3.5	Grand River	510	510	37	.13	480	480	33	.11
	River Basin Group 2.3 Total	1,010	980	31	.09	1,005	980	28	.08
2.4.1	Muskegon River	38	38	67	.04	34	34	65	.03
2.4.2	Sable Complex	38	0	84	.07	42	0	86	.08
2.4.3	Manistee River	56	50	95	.10	67	60	97	.12
2.4.4	Traverse Complex	38	4	78	.05	45	34	83	.06
2.4.5	Seul Choix-Groscap Complex	14	0	100	.10	14	0	100	.01
2.4.6	Manistique River	40	40	40	.10	52	52	100	.14
2.4.7	Bay De Noc Complex	16	4	100	.05	23	6.4	100	.08
2.4.8	Escanaba River	33	33	100	.14	38	38	100	.16
	River Basin Group 2.4 Total	273	169	89	.07	315	194	91	.08

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE HURON
WY 1977, WY 1978

Hydrologic Area		Total Phosphorus 1977				Total Phosphorus 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Diffuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Diffuse	Unit[4] Area
3.1.1	Les Cheneaux Complex	160	85	100	.31	190	72	100	.51
3.1.2	Cheboygan River	13	18	91	1.2	30	30	95	.07
3.1.3	Presque Isle Complex	4.3	0	100	.04	6.5	0	100	.04
3.1.4	Thunder Bay River	11	11	59	.02	11	11	59	.02
3.1.5	Au Sable and Alcona Complex	16	14	91	.02	24	22	94	.04
3.1.6	Rifle-Au Gres Complex	36	15	48	.06	49	23	62	.11
	River Basin Group 3.1 Total	245	143	88	.10	310	158	92	.14
3.2.1	Kawkawlin Complex	6	0	100	.06	11	0	100	.11
3.2.2	Saginaw River	510	510	18	.06	600	600	30	.11
3.2.3	Thumb Complex	30	0	68	.06	51	0	81	.11
	River Basin Group 3.2 Total	546	510	21	.06	662	600	35	.11

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE ERIE
WY 1977, WY 1978

Hydrologic Area		Total Phosphorus 1977				Total Phosphorus 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
4.1.1	Black River	32	32	5	.01				
4.1.2	St. Clair Complex	37	6	84	.32				
4.1.3	Clinton River	120	120	31	.19				
4.1.4	Rouge Complex	330	200	99	1.7				
4.1.5	Huron River	30	30	0	---				
4.1.6	Swan Creek Complex	32	0	100	.37				
4.1.7	Raisin River	180	160	67	.37				
	River Basin Group 4.1 Total	761	548	72	.41				
4.2.1	Ottawa River	35	0	86	.48				
4.2.2	Maumee River	1,700	1,700	59	.58				
4.2.3	Toussaint-Portage Complex	150	110	62	.35				
4.2.4	Sandusky River	240	240	80	.50				
4.2.5	Huron-Vermilion Complex	250	180	72	.67				
	River Basin Group 4.2 Total	2,375	2,230	63	.56				
4.3.1	Black-Rocky Complex	300	290	6	.12				
4.3.2	Cuyahoga River	360	360	0	---				
4.3.3	Chagrin Complex	86	81	56	.63				
4.3.4	Grand River	88	88	61	.25				
4.3.5	Ashtabula-Conneaut Complex	60	41	24	.26				
	River Basin Group 4.3 Total	894	860	15	.16				
4.4.1	Erie-Chautauqua Complex	190	0	80	.92				
4.4.2	Cattaraugus Creek	250	250	91	1.6				
4.4.3	Tonawanda Complex	660	130	56	1.8				
	River Basin Group 4.4 Total	1,100	380	68	1.1				

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE ONTARIO
WY 1977, WY 1978

Hydrologic Area		Total Phosporus 1977				Total Phosporus 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
5.1.1	Niagara-Orleans Complex	110	0	57	.23	110	0	59	.25
5.1.2	Genesee River	310	300	36	.15	420	400	53	.32
	River Basin Group 5.1 Total	420	300	40	.19	530	400	54	.31
5.2.1	Wayne-Cayuga Complex	31	0	92	.23	35	0	92	.25
5.2.2	Oswego River	800	800	37	.23	750	750	33	.19
5.2.3	Salmon Complex	60	0	92	.23	57	0	92	.22
	River Basin Group 5.2 Total	891	800	43	.23	842	750	40	.19
5.3.1	Black River	150	150	55	.15	190	190	64	.24
5.3.2	Perch Complex	19	0	100	.15	31	0	100	.24
5.3.3	Oswagatchie River	70	70	96	.15	100	100	97	.22
5.3.4	Grass-Raquette-St. Regis Comp.	250	170	76	.23	300	200	80	.29
	River Basin Group 5.3 Total	489	290	72	.19	621	490	78	.26

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[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE SUPERIOR

WY 1977, WY 1978

Hydrologic Area		Soluble Ortho Phosphorus 1977				Soluble Ortho Phosphorus 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
1.1.1	Superior Slope Complex	11	0	100	.018	7.1	0	100	.012
1.1.2	Saint Louis River	17	17	51	.009	20	0	57	.012
1.1.3	Apostle Island Complex	20	6.8	100	.039	26	8.9	100	.050
1.1.4	Bad River	16	16	96	.059	11	11	93	.038
1.1.5	Montreal River Complex	5.1	4.2	18	.059	6.6	6.2	27	.022
	River Basin Group 1.1 Total	69.1	44.0	80	.023	70.7	26.1	80	.024
1.2.1	Porcupine Mountains Complex	3.7	0.8	65	.008	3.1	0.6	58	.006
1.2.2	Ontonagon River	17	17	96	.046	16	16	96	.044
1.2.3	Keweenaw Peninsula Complex	10	0	100	.030	14	0	100	.039
1.2.4	Sturgeon River	2.5	2.5	100	.014	6.2	6.2	100	.034
1.2.5	Huron Mountain Complex	26	0	9	.010	28	0	13	.014
1.2.6	Grand Marais Complex	3.6	0	83	.010	5.0	0	88	.014
1.2.7	Tahquamenon River	2.6	2.6	44	.005	4.7	4.7	69	.015
1.2.8	Sault Complex	4.6	0	100	.066	4.6	0	100	.066
	River Basin Group 1.2 Total	70.0	22.9	61	.021	81.6	27.5	65	.026

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[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE MICHIGAN
WY 1977, WY 1978

Hydrologic Area		Soluble Ortho Phosphorus 1977				Soluble Ortho Phosphorus 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Diffuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Diffuse	Unit[4] Area
2.1.1	Menominee Complex	1.1	0	100	.004	1.1	0.5	100	.004
2.1.2	Menominee River	6.6	6.6	0	----	19	19	0	----
2.1.3	Peshtigo River	5.0	5.0	0	----	32	32	58	.062
2.1.4	Oconto River	10	10	87	.034	3.1	3.1	58	.007
2.1.5	Suamico Complex	1.4	0.5	100	.011	8.3	2.9	100	.066
2.1.6	Fox River	70	70	0	----	190	190	60	.066
2.1.7	Green Bay Complex	67	39	77	.084	190	100	92	.277
	River Basin Group 2.1 Total	161.1	131.1	39	.014	453.4	347.5	69	.072
2.2.1	Chicago-Milwaukee Complex	150	6.7	39	.101	290	29	67	.320
2.3.1	Saint Joseph River	61	61	0	----	49	49	0	----
2.3.2	Black River (S.Haven) Complex	9.8	0	69	.073	7.5	0	60	.049
2.3.3	Kalamazoo River	72	72	0	----	67	67	0	----
2.3.4	Black River (Ottawa Co.) Comp.	8.1	0	59	.073	6.5	0	49	.049
2.3.5	Grand River	270	270	40	.073	230	230	30	.049
	River Basin Group 2.3 Total	420.9	403	28	.035	360	346	22	.024
2.4.1	Muskegon River	6.5	6.5	17	.002	11	11	53	.008
2.4.2	Sable Complex	11	0	72	.017	10	0	71	.016
2.4.3	Manistee River	18	16	94	.032	14	12	91	.024
2.4.4	Traverse Complex	21	0	80	.026	20	1.5	79	.024
2.4.5	Seul Choix-Groscap Complex	3.7	0	100	.026	4.2	0	100	.029
2.4.6	Manistique River	7.2	7.2	100	.019	11	11	100	.029
2.4.7	Bay De Noc Complex	2.5	0.7	100	.008	1.4	0.4	100	.005
2.4.8	Escanaba River	16	16.2	100	.068	16	16	100	.068
	River Basin Group 2.4 Total	85.9	46.6	84	.021	87.6	51.9	85	.021

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[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE HURON

WY 1977, WY 1978

Hydrologic Area		Soluble Ortho Phosphorus 1977				Soluble Ortho Phosphorus 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Diffuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Diffuse	Unit[4] Area
3.1.1	Les Cheneaux Complex	30	7.1	100	.100	53	12	100	.174
3.1.2	Cheboygan River	2.0	2.0	61	.003	2.7	2.7	70	.005
3.1.3	Presque Isle Complex	0.7	0	100	.005	0.7	0	100	.005
3.1.4	Thunder Bay River	2.1	2.1	0	----	1.8	1.8	0	----
3.1.5	Au Sable and Alcona Complex	4.9	4.5	85	.007	4.1	3.8	83	.006
3.1.6	Rifle-Au Gres Complex	10	2.6	16	.009	13	4.8	29	.013
	River Basin Group 3.1 Total	49.7	18.3	77	.018	112.2	25.1	56	.030
3.2.1	Kawkawlin Complex	5.7	0	90	.051	2.5	0	76	.019
3.2.2	Saginaw River	290	290	28	.051	240	240	13	.019
3.2.3	Thumb Complex	24	0	80	.051	12	0	57	.019
	River Basin Group 3.2 Total	319.7	290	33	.051	254.5	240	15	.019

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[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE ERIE

WY 1977, WY 1978

Hydrologic Area		Soluble Ortho Phosphorus 1977				Soluble Ortho Phosphorus 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Diffuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Diffuse	Unit[4] Area
4.1.1	Black River	9.8	9.8	0	----				
4.1.2	St. Clair Complex	3.3	2.7	9	.002				
4.1.3	Clinton River	60	60	30	.092				
4.1.4	Rouge Complex	130	82	99	.706				
4.1.5	Huron River	9.6	9.6	0	----				
4.1.6	Swan Creek Complex	15	0	100	.173				
4.1.7	Raisin River	86	78	66	.173				
	River Basin Group 4.1 Total	313.7	242.1	71	.166				
4.2.1	Ottawa River	14	0	82	.173				
4.2.2	Maumee River	350	350	0	----				
4.2.3	Toussaint-Portage Complex	48	38	40	.071				
4.2.4	Sandusky River	60	60	59	.089				
4.2.5	Huron-Vermilion Complex	54	45	37	.075				
	River Basin Group 4.2 Total	526	493	16	.032				
4.3.1	Black-Rocky Complex	120	120	0	----				
4.3.2	Cuyahoga River	150	150	0	----				
4.3.3	Chagrin Complex	22	21	11	.035				
4.3.4	Grand River	23	23	25	.027				
4.3.5	Ashtabula-Conneaut Complex	1.5	1.4	0	----				
	River Basin Group 4.3 Total	316.5	315.4	3	.013				
4.4.1	Erie-Chautauqua Complex	24	0	19	.027				
4.4.2	Cattaraugus Creek	3.8	3.8	0	----				
4.4.3	Tonawanda Complex	150	0	0	----				
	River Basin Group 4.4 Total	177.8	3.8	3	.007				

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE ONTARIO
WY 1977, WY 1978

Hydrologic Area		Soluble Ortho Phosphorus 1977				Soluble Ortho Phosphorus 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
5.1.1	Niagara-Orleans Complex	23	0	0	----	32	0	27	.031
5.1.2	Genesee River	91	91	0	----	120	120	18	.031
	River Basin Group 5.1 Total	114	91	0	----	152	120	20	.031
5.2.1	Wayne-Cayuga Complex	17	0	100	.130	5.2	0	75	.031
5.2.2	Oswego River	430	430	41	.130	240	240	0	----
5.2.3	Salmon Complex	45	0	95	.176	11	0	78	.034
	River Basin Group 5.2 Total	492	430	48	.134	266	240	5	.007
5.3.1	Black River	27	27	0	----	52	52	37	.037
5.3.2	Perch Complex	3.9	0	100	.031	4.8	0	100	.038
5.3.3	Oswagatchie River	15	15	90	.031	18	18	92	.039
5.3.4	Grass-Raquette-St. Regis Comp.	52	42	44	.028	59	46	50	.035
	River Basin Group 5.3 Total	97.9	84	51	.026	134	116	52	.037

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[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE SUPERIOR

WY 1977, WY 1978

Hydrologic Area		Suspended Solids 1977				Suspended Solids 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
1.1.1	Superior Slope Complex	26,000	0	100	43	42,000	0	100	70
1.1.2	Saint Louis River	9,100*	9,100*	0	----	100,000	100,000	99	110
1.1.3	Apostle Island Complex	190,000	64,000	100	360	370,000	130,000	100	720
1.1.4	Bad River	43,000	43,000	100	170	20,000	20,000	100	77
1.1.5	Montreal River Complex	3,400	1,200	100	19	1,100	900	94	13
	River Basin Group 1.1 Total	271,500	117,300	95	110	533,100	250,900	100	220
1.2.1	Porcupine Mountains Complex	3,400	1,100	93	12	4,500	1,500	100	16
1.2.2	Ontonagon River **	220,000	220,000	100	620**	120,000	120,000	100	340
1.2.3	Keweenaw Peninsula Complex	17,000	0	100	48	17,000	0	100	48
1.2.4	Sturgeon River	40,000	40,000	100	220	19,000	19,000	100	100
1.2.5	Huron Mountain Complex	2,300	480	88	8.2	2,300	0	88	8
1.2.6	Grand Marais Complex	16,000	0	100	52	4,700	0	99	15
1.2.7	Tahquamenon River	21,000	21,000	100	95	4,400	4,400	100	20
1.2.8	Sault Complex	3,600	0	100	52	1,400	0	100	20
	River Basin Group 1.2 Total	323,300	282,580	99	160	173,300	144,900	99	85

*Over 46,000 MT/yr from upstream point sources.

**Drains a large clay area

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[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE MICHIGAN
WY 1977, WY 1978

Hydrologic Area		Suspended Solids 1977				Suspended Solids 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
2.1.1	Menominee Complex	5,300	2,300	100	19	20,000	8,800	100	74
2.1.2	Menominee River	7,300	7,300	75	5.2	21,000	21,000	91	18
2.1.3	Peshtigo River	3,500	3,500	94	11	6,000	6,000	98	19
2.1.4	Oconto River	7,700	7,700	83	25	4,400	4,400	71	12
2.1.5	Suamico Complex **	610	210	100	4.9	1,000	360	100	8.1
2.1.6	Fox River	46,000	46,000	79	21	170,000	170,000	94	94
2.1.7	Green Bay Complex	16,000	8,300	98	25	72,000	38,000	100	120
	River Basin Group 2.1 Total	86,410	75,310	84	17	294,400	248,560	96	64
2.2.1	Chicago-Milwaukee Complex	33,000	12,000	85	50	10,000	44,000	94	180
2.3.1	Saint Joseph River	69,000	69,000	94	53	72,000	72,000	88	56
2.3.2	Black River (S.Haven) Complex	4,400	0	98	46	5,200	0	98	55
2.3.3	Kalamazoo River	23,000	23,000	88	39	31,000	31,000	91	54
2.3.4	Black River (Ottawa Co.) Comp.	2,500	0	87	34	3,300	0	93	47
2.3.5	Grand River	47,000	47,000	88	28	63,000	63,000	91	39
	River Basin Group 2.3 Total	145,900	139,000	91	40	174,500	166,000	90	47
2.4.1	Muskegon River	16,000	16,000	99	22	24,000	24,000	99	34
2.4.2	Sable Complex	11,000	0	97	23	15,000	0	98	31
2.4.3	Manistee River	14,000	13,000	87	24	17,000	15,000	100	29
2.4.4	Traverse Complex	8,800	480	98	14	11,000	700	99	18
2.4.5	Seul Choix-Groscap Complex	4,100	0	100	29	4,500	0	100	32
2.4.6	Manistique River	11,000	11,000	100	29	12,000	12,000	100	32
2.4.7	Bay De Noc Complex	7,600	2,100	100	26	8,600	2,400	100	29
2.4.8	Escanaba River	3,400	3,400	95	14	6,400	6,400	100	27
	River Basin Group 2.4 Total	75,900	45,980	96	21	98,500	60,500	99	28

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[*] Point sources to the Indiana Harbor Canal and Burns Ditch are considered direct; see page 87.

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

**The source of data for the Suamico Complex is the Pensaukee river which is very flashy.

Table 4

HYDROLOGIC AREA LOADS

LAKE HURON
WY 1977, WY 1978

Hydrologic Area		Suspended Solids 1977				Suspended Solids 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
3.1.1	Les Cheneaux Complex *	160,000	110,000	100	190	130,000	81,000	100	190
3.1.2	Cheboygan River	4,300	4,300	99	10	3,200	3,200	99	7.6
3.1.3	Presque Isle Complex	1,300	0	100	8.9	1,100	0	100	7.3
3.1.4	Thunder Bay River	2,500	2,500	94	7.3	2,400	2,400	93	6.9
3.1.5	Au Sable and Alcona Complex	3,000	2,700	99	5.2	6,400	5,900	100	11
3.1.6	Rifle-Au Gres Complex	12,000	7,000	99	42	31,000	17,700	100	110
	River Basin Group 3.1 Total	183,100	126,500	99	86	174,100	110,200	97	80
3.2.1	Kawkawlin Complex	3,700	0	100	37	9,600	0	100	95
3.2.2	Saginaw River	64,000	64,000	81	32	150.000	150,000	92	84
3.2.3	Thumb Complex	12,000	0	100	32	31,000	0	100	84
	River Basin Group 3.2 Total	79,700	64,000	85	32	190,600	150,000	93	85

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[*] Based on the Pine River which is very flashy

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE ERIE
WY 1977, WY 1978

Hydrologic Area		Suspended Solids 1977				Suspended Solids 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
4.1.1	Black River	9,300	9,300	100	51				
4.1.2	St. Clair Complex	2,900	1,000	99	20				
4.1.3	Clinton River	30,000	30,000	92	140				
4.1.4	Rouge Complex	95,000	58,000	100	500				
4.1.5	Huron River	6,500	6,500	76	22				
4.1.6	Swan Creek Complex	13,000	0	100	150				
4.1.7	Raisin River	50,000	42,000	98	150				
	River Basin Group 4.1 Total	206,700	146,800	97	150				
4.2.1	Ottawa River	9,600	0	100	150				
4.2.2	Maumee River	800,000	800,000	99	460				
4.2.3	Toussaint-Portage Complex	64,000	38,000	99	240				
4.2.4	Sandusky River	100,000	100,000	99	250				
4.2.5	Huron-Vermilion Complex	190,000	120,000	100	700				
	River Basin Group 4.2 Total	1,163,600	1,058,000	99	430				
4.3.1	Black-Rocky Complex	200,000	170,000	100	850				
4.3.2	Cuyahoga River	120,000	120,000	92	460				
4.3.3	Chagrin Complex	110,000	98,000	100	1,400				
4.3.4	Grand River	69,000	69,000	100	320				
4.3.5	Ashtabula-Conneaut Complex	39,000	37,000	99	430				
	River Basin Group 4.3 Total	538,000	494,000	97	620				
4.4.1	Erie-Chautauqua Complex	310,000	0	100	1,800				
4.4.2	Cattaraugus Creek	460,000	460,000	100	3,200				
4.4.3	Tonawanda Complex	280,000	95,000	99	1,100				
	River Basin Group 4.4 Total	1,050,000	555,000	99	1,500				

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE ONTARIO

WY 1977, WY 1978

Hydrologic Area		Suspended Solids 1977				Suspended Solids 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
5.1.1	Niagara-Orleans Complex	74,000	0	99	270	74,000	0	99	270
5.1.2	Genesee River	1,100,000	1,000,000	100	1,500	480,000	440,000	99	680
	River Basin Group 5.1 Total	1,174,000	1,000,000	100	1,300	554,000	440,000	99	600
5.2.1	Wayne-Cayuga Complex	6,500	0	100	51	14,000	0	100	110
5.2.2	Oswego River	86,000	86,000	79	51	160,000	160,000	89	110
5.2.3	Salmon Complex	11,000	0	100	45	32,000	0	100	130
	River Basin Group 5.2 Total	103,500	86,000	82	48	206,000	160,000	91	110
5.3.1	Black River	25,000	25,000	83	39	85,000	85,000	95	150
5.3.2	Perch Complex	4,100	0	100	33	4,700	0	100	37
5.3.3	Oswagatchie River	11,000	11,000	100	26	16,000	16,000	100	37
5.3.4	Grass-Raquette-St. Regis Comp	14,000	8,500	98	17	16,000	9,800	98	19
	River Basin Group 5.3 Total	54,100	44,500	92	26	121,700	110,800	97	62

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE SUPERIOR
WY 1977, WY 1978

Hydrologic Area		Chloride 1977				Chloride 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
1.1.1	Superior Slope Complex	3,600	0	100	6.0	6,000	0	100	10
1.1.2	Saint Louis River	16,000	16,000	72	12.0	25,000	25,000	82	22
1.1.3	Apostle Island Complex	2,800	970	100	5.5	4,500	1.100	100	8.7
1.1.4	Bad River	2,000	2.000	98	7.6	2,000	0	98	7.5
1.1.5	Montreal River Complex	7,000	5,700	95	8.5	7,000	0	95	35
	River Basin Group 1.1 Total	31,400	24,670	84	11.0	44,500	26,100	89	17
1.2.1	Porcupine Mountains Complex	34,000*	410	4	4.4	35,000	610	95	6.4
1.2.2	Ontonagon River	2,400	2,400	98	6.7	4,100	4,100	99	11
1.2.3	Keweenaw Peninsula Complex	2,200	0	100	6.2	4,200	0	100	12
1.2.4	Sturgeon River	1,000	1,000	100	5.8	2,400	2,400	100	13
1.2.5	Huron Mountain Complex	3,400	920	70	11.	6,000	0	75	18
1.2.6	Grand Marais Complex	3,200	0	95	9.9	4,700	0	96	14
1.2.7	Tahquamenon River	2,000	2,000	96	8.9	2,400	2,500	97	11
1.2.8	Sault Complex	620	0	100	8.9	760	0	100	11
	River Basin Group 1.2 Total	48,820	6,730	31	7.4	59,560	9,610	41	12

*33.000 Metric Tons/Yr from point sources on the Mineral River

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[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE MICHIGAN
WY 1977, WY 1978

Hydrologic Area		Chloride 1977				Chloride 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
2.1.1	Menominee Complex	1,200	550	100	4.6	2,300	1,000	100	8.6
2.1.2	Menominee River	5,200	5,200	62	3.0	7,800	7,800	74	5.4
2.1.3	Peshtigo River	2,500	2,500	59	4.9	3,600	0	72	8.8
2.1.4	Oconto River	4,800	4,800	98	18.	8,500	0	99	33
2.1.5	Suamico Complex	1,200	410	100	9.3	2,100	0	100	17
2.1.6	Fox River	36,000	36,000	55	11	53,000	53,000	69	21
2.1.7	Green Bay Complex	13,000	7,000	86	18	21,000	0	91	32
	River Basin Group 2.1 Total	63,900	56,460	66	9.7	98,300	61,800	78	18
2.2.1	Chicago-Milwaukee Complex*	54,000	14,000	51	48	72,000	17,000	63	81
2.3.1	Saint Joseph River	68,000	68,000	66	37	73,000	73,000	69	41
2.3.2	Black River (S.Haven) Complex	5,300	0	91	52	6,200	0	92	62
2.3.3	Kalamazoo River	48,000	48,000	71	66	57,000	57,000	75	83
2.3.4	Black River (Ottawa Co.) Comp.	5,000	0	74	56	6,000	0	78	71
2.3.5	Grand River	96,000	96,000	69	45	120,000	120,000	74	59
	River Basin Group 2.3 Total	222,300	212,000	69	46	262,200	250,000	73	57
2.4.1	Muskegon River	35,000	35,000	97	48	39,000	39,000	98	54
2.4.2	Sable Complex	15,000	0	96	31	17,000	0	97	36
2.4.3	Manistee River	76,000	75,000	1	13	73,000	72,000	1	18
2.4.4	Traverse Complex	9,600	1,700	92	13	13,000	2,100	83	18
2.4.5	Seul Choix-Groscap Complex	1,100	0	100	8.0	1,600	0	100	11
2.4.6	Manistique River	3,000	3,000	100	8.0	4,200	4,200	100	11
2.4.7	Bay De Noc Complex	3,300	920	100	11	2,400	660	100	79
2.4.8	Escanaba River	7,000	7,000	100	30	7,600	7,600	100	32
	River Basin Group 2.4 Total	150,000	122,620	48	21	157,800	125,560	52	24

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[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

*Point sources to the Indiana Harbor Cnaal andBurns Ditch are considered direct; see page 87

Table 4

HYDROLOGIC AREA LOADS

LAKE HURON
WY 1977, WY 1978

Hydrologic Area		Chloride 1977				Chloride 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
3.1.1	Les Cheneaux Complex	2,200	510	100	7.2	3,000	690	100	9.7
3.1.2	Cheboygan River	5,200	5,200	95	12	6,800	6,800	96	16
3.1.3	Presque Isle Complex	1,400	0	100	9.5	1,800	0	100	12
3.1.4	Thunder Bay River	3,100	3,100	72	6.8	3,800	3,800	77	9.1
3.1.5	Au Sable and Alcona Complex	7,500	6,900	99	13	8,600	7,800	99	15
3.1.6	Rifle-Au Gres Complex	11,000	6,200	97	37.	17,000	9,600	98	58
	River Basin Group 3.1 Total	30,400	21,910	95	14.	41,000	28,690	96	19.
3.2.1	Kawkawlin Complex	3,800	0	98	37	5,800	0	99	58
3.2.2	Saginaw River	160,000	160,000	18	17	200,000	200,000	36	46
3.2.3	Thumb Complex	6,400	0	98	17	17,000	0	99	46
	River Basin Group 3.2 Total	170,200	160,000	22	18	222,800	200,000	43	46

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE ERIE
WY 1977, WY 1978

Hydrologic Area		Chloride 1977				Chloride 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
4.1.1	Black River	5,600	5,600	96	30				
4.1.2	St. Clair Complex	8,100	2,900	98	54				
4.1.3	Clinton River	56,100	56,000	77	22				
4.1.4	Rouge Complex	100,000	74,000	99	390				
4.1.5	Huron River	23,000	23,000	64	66				
4.1.6	Swan Creek Complex	4,200	0	100	69				
4.1.7	Raisin River	21,000	18,300	78	49				
	River Basin Group 4.1 Total	218,000	179,800	89	140				
4.2.1	Ottawa River	3,300	0	97	50				
4.2.2	Maumee River	120,000	120,000	69	50				
4.2.3	Toussaint-Portage Complex	20,000	13,000	84	65				
4.2.4	Sandusky River	29,000	29,000	88	65				
4.2.5	Huron-Vermilion Complex	21,000	5,400	92	71				
	River Basin Group 4.2 Total	193,300	167,400	78	56				
4.3.1	Black-Rocky Complex	25,000	23,000	47	50				
4.3.2	Cuyahoga River	71,000	71,000	34	100				
4.3.3	Chagrin Complex	18,000	16,000	92	210				
4.3.4	Grand River	18,000	18,000	93	77				
4.3.5	Ashtabula-Conneaut Complex	8,800	7,800	80	78				
	River Basin Group 4.3 Total	140,800	135,800	53	89				
4.4.1	Erie-Chautauqua Complex	12,000	0	90	66				
4.4.2	Cattaraugus Creek	8,100	8,100	94	53				
4.4.3	Tonawanda Complex	20,000	2,900	72	77				
	River Basin Group 4.4 Total	40,100	11,000	82	48				

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 4

HYDROLOGIC AREA LOADS

LAKE ONTARIO
WY 1977, WY 1978

Hydrologic Area		Chloride 1977				Chloride 1978			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
5.1.1	Niagara-Orleans Complex	17,000	0	82	53	17,000	0	82	53
5.1.2	Genesee River	150,000	140,000	94	200	230,000	210,000	96	320
	River Basin Group 5.1 Total	167,000	140,000	93	170	247,000	210,000	95	260
5.2.1	Wayne-Cayuga Complex	6,900	0	98	53	6,900	0	98	53
5.2.2	Oswego River	960,000	960,000	43	310	1,200,000	1,200,000	52	460
5.2.3	Salmon Complex	3,700	0	93	14	3,000	0	91	11
	River Basin Group 5.2 Total	970,600	960,000	43	240	1,209,900	1,200,000	51	350
5.3.1	Black River	10,000	10,000	73	14	8,500	8,500	68	11
5.3.2	Perch Complex	1,700	0	100	14	1,400	0	100	11
5.3.3	Oswagatchie River	5,700	5,700	98	13	5,400	5,400	98	12
5.3.4	Grass-Raquette-St. Regis Comp.	11,000	7,200	83	11	17,000	11,000	89	18
	River Basin Group 5.3 Total	28,400	22,900	84	12	32,300	24,900	86	14

[1] Tocal load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 5

U.S. GREAT LAKES

TRIBUTARY LOADINGS
WY 1975, WY 1976

LAKE		Total Phosphorus 1975				Total Phosphorus 1976			
NUMBER	NAME	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit Area
1	Lake Superior	1,389	999	90	.28	964	464	86	.20
2	Lake Michigan	3,190	2,772	55	.15	3,596	3,062	63	.19
3	Lake Huron	1,720	1,472	66	.27	1,954	1,563	83	.40
4	Lake Erie	8,639	6,899	81	1.3	7,112	5,953	71	.91
5	Lake Ontario •	1,966	1,424	53	.23	3,513	2,580	72	.56
	TOTAL	16,904	13,566	81	.40	17,139	13,622	72	.40
LAKE		Soluble Ortho Phosphorus 1975				Soluble Ortho Phosphorus 1976			
1	Lake Superior	464	133	88	.09	361	86	86	.07
2	Lake Michigan	1,224	1,055	56	.06	1,153	933	55	.05
3	Lake Huron	456	365	45	.05	843	663	83	.17
4	Lake Erie*	2,070	1,320	62	.23	2,104	945	45	.17
5	Lake Ontario	522	374	45	.05	549	416	32	.04
	TOTAL	4,736	3,247	60	.10	5,010	3,043	55	.09
Lake		Suspended Solids 1975				Suspended Solids 1976			
1	Lake Superior	1,380,000	1,011,200	96	300	720,800	477,030	93	150
2	Lake Michigan	608,800	455,700	93	49	742,400	602,100	95	57
3	Lake Huron	467,300	256,300	98	110	765,100	424,100	99	180
4	Lake Erie*	6,054,000	3,822,000	99	1,100	4,206,900	2,927,000	98	740
5	Lake Ontario	1,054,000	779,000	95	220	1545,000	1,316,000	96	330
	TOTAL	9,565,000	6,324,200	98	310	7,980,200	5,716,230	97	250

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

*1978 Lake Erie data not available (NA)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 5

U.S. GREAT LAKES

TRIBUTARY LOADINGS
WY 1975, WY 1976

LAKE		Chloride 1975				Chloride 1976			
NUMBER	NAME	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
1	Lake Superior	92,680	50,520	61	13	81,600	26,680	55	10
2	Lake Michigan	775,500	636,960	65	43	711,600	563,650	72	42
3	Lake Huron	377,400	351,290	66	60	422,100	359,030	70	74
4	Lake Erie*	855,600	577,800	90	91	696,900	463,900	80	100
5	Lake Ontario	1,199,900	1,149,200	52	140	1,607,800	1,553,300	64	220
	TOTAL*	3,301,080	2,756,770	66	74	3,520,000	2,966,500	69	80

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[*] 1978 Lake Erie data not available (NA)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 6

HYDROLOGIC AREA LOADS

LAKE ERIE

WY 1975, WY 1976

Hydrologic Area		Total Phosphorus 1975				Total Phosphorus 1976			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Diffuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Diffuse	Unit[4] Area
4.1.1	Black River	46	46	86	.22	130	130	76	.53
4.1.2	St. Clair Complex	64	23	92	.40	200	110	97	1.0
4.1.3	Clinton River	260	260	58	.76	160	160	48	.06
4.1.4	Rouge Complex	320	200	96	1.6	740	450	99	3.9
4.1.5	Huron River	250	250	60	.70	48	48	0	-----
4.1.6	Swan Creek Complex	60	0	100	.70	66	0	100	.77
4.1.7	Raisin River	310	280	72	.70	310	270	81	.77
	River Basin Group 4.1 Total	1,310	1,059	76	.74	1,654	1,168	86	1.06
4.2.1	Ottawa River	69	0	95	1.0	90	0	95	1.3
4.2.2	Maumee River	2,600	2,600	86	1.3	3,000	3,000	76	1.3
4.2.3	Toussaint-Portage Complex	240	150	85	.77	100	86	44	.12
4.2.4	Sandusky River	630	600	81	1.3	360	360	87	.79
4.2.5	Huron-Vermilion Complex	310	220	86	1.0	110	84	64	.19
	River Basin Group 4.2 Total	3,839	3,570	85	1.2	3,660	3,530	76	1.03
4.3.1	Black-Rocky Complex	750	660	76	2.5	64	40	36	.21
4.3.2	Cuyahoga River	790	790	65	2.2	420	420	0	----
4.3.3	Chagrin Complex	160	140	96	2.0	40	40	7	.03
4.3.4	Grand River	380	330	100	1.8	210	210	84	.82
4.3.5	Ashtabula-Conneaut Complex	190	170	97	2.0	64	45	29	.21
	River Basin Group 4.3 Total	2,270	2,090	79	2.1	798	755	28	.26
4.4.1	Erie-Chautauqua Complex	300	0	92	1.6	220	0	83	1.1
4.4.2	Cattaraugus Creek	180	180	94	1.2	310	310	92	2.0
4.4.3	Tonawanda Complex	740	0	63	1.6	470	190	38	1.0
	River Basin Group 4.4 Total	1,220	180	75	1.5	1,000	500	65	1.0

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 6

HYDROLOGIC AREA LOADS

LAKE ERIE
WY 1975, WY 1976

Hydrologic Area		Soluble Ortho Phosphorus 1975				Soluble Ortho Phosphorus 1976			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
4.1.1	Black River	26	26	87	.12	38	0	61	.13
4.1.2	St. Clair Complex	21	0	89	.12	66	47	95	.43
4.1.3	Clinton River	78	0	32	.12	130	0	67	.43
4.1.4	Rouge Complex	170	110	96	.86	160	0	100	.86
4.1.5	Huron River	40	40	0	----	49	0	0	----
4.1.6	Swan Creek Complex	11	0	100	.12	17	0	100	.20
4.1.7	Raisin River	100	0	58	.18	96	86	69	.20
	River Basin Group 4.1 Total	446	176	67	.22	556	133	75	.31
4.2.1	Ottawa River	17	0	90	.24	12	0	79	.15
4.2.2	Maumee River	610	610	68	.24	600	600	41	.15
4.2.3	Toussaint-Portage Complex	77	52	75	.22	35	30	17	.02
4.2.4	Sandusky River	85	83	31	.07	69	69	64	.11
4.2.5	Huron-Vermilion Complex	55	44	59	.12	59	33	42	.09
	River Basin Group 4.2 Total	844	789	64	.20	775	732	43	.12
4.3.1	Black-Rocky Complex	320	140	72	1.0	190	0	12	.10
4.3.2	Cuyahoga River	180	180	32	.25	180	0	0	----
4.3.3	Chagrin Complex	24	22	85	.26	42	0	55	.30
4.3.4	Grand River	57	0	99	.26	80	80	79	.30
4.3.5	Ashtabula-Conneaut Complex	27	0	89	.26	53	0	51	.30
	River Basin Group 4.3 Total	608	342	64	.47	545	80	25	.16
4.4.1	Erie-Chautauqua Complex	39	0	67	.16	49	0	60	.18
4.4.2	Cattaraugus Creek	13	13	54	.05	19	0	38	.05
4.4.3	Tonawanda Complex	120	0	12	.05	160	0	12	.05
	River Basin Group 4.4 Total	172	13	28	.07	228	0	24	.08

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[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 6

HYDROLOGIC AREA LOADS

LAKE ERIE

WY 1975, WY 1976

Hydrologic Area		Suspended Solids 1975				Suspended Solids 1976			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
4.1.1	Black River	16,000	16,000	100	86	16,000	0	100	86
4.1.2	St. Clair Complex	13,000	0	100	86	65,000	46,000	100	440
4.1.3	Clinton River	18,000	0	96	86	110,000	110,000	98	550
4.1.4	Rouge Complex	23,000	17,000	26	86	100,000	0	100	550
4.1.5	Huron River	23,000	23,000	82	92	22,000	0	93	92
4.1.6	Swan Creek Complex	7,900	0	100	92	7,900	0	100	92
4.1.7	Raisin River	150,000	0	99	460	170,000	150,000	100	530
	River Basin Group 4.1 Total	250,900	56,000	91	177	490,900	306,000	99	370
4.2.1	Ottawa River	54,000	0	100	840	65,000	0	100	1,000
4.2.2	Maumee River	1,400,000	1,400,000	100	840	1,740,000	1,740,000	100	1,000
4.2.3	Toussaint-Portage Complex	110,000	66,000	100	420	46,000	27,000	99	170
4.2.4	Sandusky River	340,000	320,000	100	860	180,000	180,000	100	460
4.2.5	Huron-Vermilion Complex	280,000	180,000	100	1,000	110,000	70,000	100	400
	River Basin Group 4.2 Total	2,184,000	1,966,000	100	817	2,141,000	2,017,000	100	790
4.3.1	Black-Rocky Complex	460,000	240,000	100	2,000	50,000	43,000	95	210
4.3.2	Cuyahoga River	630,000	630,000	99	2,700	130,000	130,000	93	530
4.3.3	Chagrin Complex	270,000	250,000	100	3,600	420,000	380,000	91	4,900
4.3.4	Grand River	570,000	0	100	2,700	24,000	24,000	99	110
4.3.5	Ashtabula-Conneaut Complex	240,000	0	100	2,700	28,000	27,000	99	310
	River Basin Group 4.3 Total	2,170,000	1,120,000	100	2,600	652,000	604,000	93	720
4.4.1	Erie-Chautauqua Complex	450,000	0	100	2,700	53,000	0	100	310
4.4.2	Cattaraugus Creek	680,000	680,000	100	4,800	680,000	0	100	4,700
4.4.3	Tonawanda Complex	320,000	0	98	1,100	190,000	0	98	500
	River Basin Group 4.4 Total	1,450,000	680,000	100	2,300	923,000	0	99	1,300

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

Table 6

HYDROLOGIC AREA LOADS

LAKE ERIE

WY 1975, WY 1976

Hydrologic Area		Chloride 1975				Chloride 1976			
Number	Name	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area	Total[1] Load	Monitored[2] Load	%[3] Dif-fuse	Unit[4] Area
4.1.1	Black River	8,100	7,800	97	43	8,200	0	97	44
4.1.2	St. Clair Complex	6,600	0	97	43	30,000	21,000	99	200
4.1.3	Clinton River	26,000	0	52	70	44,000	44,000	71	160
4.1.4	Rouge Complex	29,000	18,000	99	150	29,000	0	99	150
4.1.5	Huron River	29,000	29,000	74	96	31,000	0	74	100
4.1.6	Swan Creek Complex	8,300	0	100	96	9,000	0	100	100
4.1.7	Raisin River	37,000	0	84	96	23,000	20,000	80	58
	River Basin Group 4.1 Total	144,000	54,800	82	87	174,200	85,000	86	110
4.2.1	Ottawa River	9,600	0	99	150	4,700	0	98	72
4.2.2	Maumee River	270,000	270,000	93	150	160,000	160,000	76	72
4.2.3	Toussaint-Portage Complex	32,000	20,000	92	110	9,000	1,900	77	84
4.2.4	Sandusky River	49,000	47,000	95	120	26,000	26,000	87	56
4.2.5	Huron-Vermilion Complex	26,000	17,000	95	92	29,000	19,000	94	100
	River Basin Group 4.2 Total	386,600	354,000	93	130	228,700	206,900	81	69
4.3.1	Black-Rocky Complex	53,000	27,000	90	210	22,000	11,000	41	39
4.3.2	Cuyahoga River	110,000	110,000	79	380	130,000	130,000	64	360
4.3.3	Chagrin Complex	24,000	22,000	99	310	23,000	21,000	94	280
4.3.4	Grand River	66,000	0	100	310	67,000	0	98	310
4.3.5	Ashtabula-Conneaut Complex	28,000	0	99	310	11,000	10,000	85	110
	River Basin Group 4.3 Total	281,000	159,000	90	300	253,000	172,000	76	230
4.4.1	Erie-Chautauqua Complex	12,000	0	94	68	13,000	0	90	69
4.4.2	Cattaraugus Creek	10,000	10,000	95	68	10,000	0	96	64
4.4.3	Tonawanda Complex	22,000	0	90	68	18,000	0	60	34
	River Basin Group 4.4 Total	44,000	10,000	92	68	41,000	0	79	47

[1] Total load from Hydrologic Area (metric tons/yr)

[2] Portion of total load that was monitored (metric tons/yr)

[3] Percent of total load from diffuse sources (nonpoint)

[4] Total diffuse unit area load (kg/hectare/yr or 10^{-1} metric tons/km^2/yr)

In tables 4 and 6 the "Total Load" column represents the total diffuse and point source load coming into the lakes from the tributaries within a given area. The "Monitored Load" column gives that portion of the total load that was calculated from existing flow and concentration field data on individual tributaries within a particular area. An estimated load was also obtained for the unmonitored areas. The estimated unmonitored load plus the monitored load equals the total load. The "Percent Diffuse" column represents that portion of the total load which is nonpoint or from diffuse sources (includes base flow). This value is obtained by subtracting all known point source loads to the tributaries of the area in question. It was assumed that 100 percent of all point source inputs within a given basin are delivered to the lake in calculating this diffuse load. The "Unit Area" column presents the total (monitored plus unmonitored area) diffuse unit area load. This value was obtained by dividing the total diffuse load by the given area.

Values presented in Tables 3 and 5 for total load and monitored load are summations of the river basin group information. The percent diffuse and unit area loads are calculated for each lake based on the diffuse load and the diffuse load divided by the drainage area of the given lake, respectively. All values presented in these tables are based upon the best available data for both river mouth and point source loading information.

The river mouth loads used to generate these tables are presented in Appendix C. This appendix updates Appendix D of the previous Post-PLUARG report entitled "Post-PLUARG Evaluation of Great Lakes Water Quality Management Studies and Programs" (Sullivan et al., 1980). The appendix provides river mouth loads obtained from either the ratio estimator method or directly from the U.S. Lake Erie Wastewater Management Study.

DISCUSSION

Flow

In order to evaluate the changes in load that occur from one year to the next, it is important to consider the natural variability in flow. Figure 1 shows mean annual flows (in cubic meters per second) for the entire U.S. portion of the basin for water years 1958 through 1978. The figure also indicates how these flows compare to the long term historical flow which is represented by the dashed line. The data used in this figure are based upon USGS gaging station records. Flows from gaged rivers were adjusted to river mouths, and flows from ungaged tributaries were estimated by extrapolating flows from the gaged areas. Figure 1 shows that the mean annual daily discharges during water years 1975 and 1976 were very high compared to the long term flow. Water year 1977 represents a significant drop in the mean annual flow while 1978 rebounded to another significantly high flow year.

This figure not only shows the year to year variability but also the significant changes that occur over a 20 year period. The early to mid-1960's represent a time of significantly low flows from U.S. tributaries, while the early to mid-1970's show a significantly high flow period.

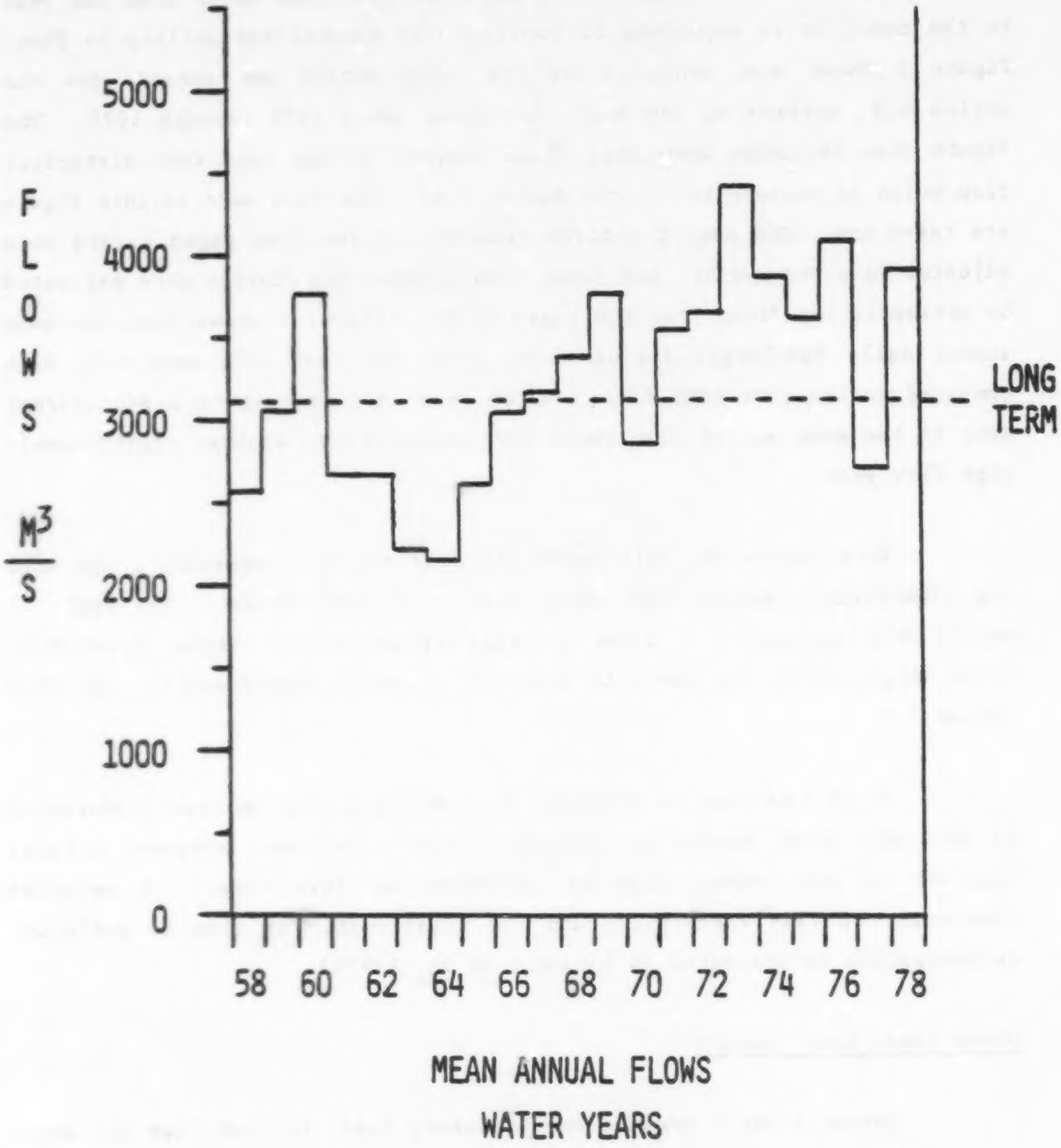
It is important to remember that within any given year differences in flow may occur during the spring period. For some streams, a large fraction of the annual load is delivered at this time. A detailed discussion of flow variability and the relationship of flow to pollutant concentration is presented in Sonzogni et al.,(1978).

Great Lakes Load Summary

Tables 3 and 5 present the tributary loads to each lake for water years 1975 through 1978 (except for 1978 Lake Erie). These loads represent best estimates utilizing the data available. Thus, it is important that an understanding of the limitations of the data be kept in mind throughout this analysis.

FIGURE 1

TOTAL U.S. TRIBUTARY FLOW



Water year 1977 stands out as a result of the dramatic decline in loads (for parameters studied) relative to 1975 and 1976 (with a few exceptions). For total phosphorus, the load from the U.S. side declined by about 6,500 mt/yr from 1976 to 1977. Significant declines are noted in all lakes, with Lake Erie showing the largest decline (from 7,100 mt/yr to 5,100 mt/yr). Total phosphorus unit area loads declined from .4 kg/ha/yr in 1975 and 1976 to .19 kg/ha/yr in 1977.

The load of soluble ortho phosphorus also showed a significant decline from 1976 to 1977. The load was reduced from 5,000 mt/yr to 3,400 mt/yr. The diffuse area load is about 0.04 kg/ha/yr as opposed to the 0.1 kg/ha/yr and 0.09 kg/ha/yr values for 1975 and 1976, respectively.

For both total phosphorus and soluble ortho phosphorus it is important to note the significant decline in the diffuse portion of the load. In 1975 about 80% of the total phosphorus river mouth load was from diffuse sources. In 1976 around 70% came from diffuse sources, while in 1977 only 55% of the total phosphorus load was diffuse. For soluble ortho phosphorus the 1975 (60%) and 1976 (55%) diffuse portions are significantly higher than the 1977 value of 35%.

Suspended solids loads declined from about 8,000,000 mt/yr in 1976 to 5,500,000 mt/yr in 1977. This corresponds to a diffuse unit area load reduction of 250 kg/ha/yr to 180 kg/ha/yr. The vast majority of the suspended solids load remains diffuse in origin.

The chloride load reduction from 1976 to 1977 amounts to 1,000,000 mt/yr (from 3,500,000 mt/yr to 2,500,000 mt/yr.).

Because of the lack of information available for Lake Erie, 1978 total comparisons cannot be made. However, by examining each lake it appears that for most parameters the loads rebound significantly above 1977 levels. This pattern would be expected due to the significant rise in flow during water year 1978 (see Table 7).

TABLE 7

U.S. GREAT LAKES TRIBUTARY

TOTAL PHOSPHORUS LOADS AND FLOW

WY 1975 TO WY 1978

	Total Lake Area	Total Phosphorus Loads from River Mouths (mt/yr)				Gaged Area	Mean Annual Flow at Gage (m^3/s)				
LAKE	(km^2)	1975	1976	1977	1978	(km^2)	1975	1976	1977	1978	Long Term
Superior	44,000	1,389	964	780	1,343	20,393	209	176	126	262	195
Michigan	117,741	3,190	3,596	2,173	3,178	83,996	852	913	524	793	749
Huron	41,920	1,720	1,954	791	972	21,883	231	277	121	174	176
Erie	55,590	8,639	7,112*	5,130	9,100**	38,678	423	428	294	489	345
Ontario	45,770	1,966	3,513	1,800	1,993	32,671	593	839	647	811	546
TOTAL	304,690	16,904	17,139	10,674	16,486**	197,621	2,308	2,633	1,712	2,529	2,011
St. Lawrence River						773,890	8,100	8,510	7,380	8,130	6,860

* Probably low because it does not include event data for 50% of the area.

** Estimated load for Lake Erie will be updated with the Lake Erie Wastewater Management Study data.

Lake Superior

Total phosphorus loads for Lake Superior exhibited a decline from 1975 through 1977 and then a significant rise in 1978. An unusually low value of 70 mt/yr was reported in 1977 for the Saint Louis River. This corresponds to a very low flow value of only 996 cfs at the gage for that year. An equally remarkable 3,755 cfs high flow was reported for water year 1978, for the Saint Louis. This flow fluctuation seems to be the major cause of the total lake load fluctuation. This is primarily because the St. Louis River is the single largest tributary draining Lake Superior from the United States side. Table 7 shows how the total phosphorus load and flow fluctuate over these four years.

The soluble ortho phosphorus loads from Lake Superior show a similar pattern but do not show a large rise in load during water year 1978. This analysis is somewhat hampered by the lack of soluble ortho phosphorus data in 1975, 1976 and 1978 for the St. Louis River.

The Lake Superior suspended solids load is relatively stable between 1976 and 1978. The 1975 value is almost twice as high as any of the other years monitored in this study.

The chloride load fluctuates very little from 1975 through 1978. A low value of 80,000 mt/yr was recorded in 1977 and a high value of 100,000 mt/yr in 1978.

Lake Michigan

Total phosphorus loading to Lake Michigan from its tributaries follows the same pattern as the tributary flow to that lake (See Table 7). 1975 and 1978 values are very similar, at 3,200 mt/yr, with 1976 showing a high of 3,600 mt/yr, and 1977 a load of 2,200 mt/yr.

The soluble ortho phosphorus loads are virtually the same for 1975, 1976 and 1978, about 1,200 mt/yr. The 1977 value, 800 mt/yr, represents a low point in the data.

Suspended solids loads range from 610,000 mt/yr to 740,000 mt/yr for water years 1975, 1976 and 1978. The 1977 value of 340,000 mt/yr is the lowest value recorded over this four years period.

The chloride loads for 1975 and 1976 are 780,000 mt/yr and 710,000 mt/yr respectively. The 1977 value of 490,000 mt/yr represents the lowest value with 1978 rising to 590,000 mt/yr.

Lake Huron

The total phosphorus load from U.S. Lake Huron tributaries follows a pattern similar to the flow from these rivers (Table 7). 1975 and 1976 show loading values of 1,700 mt/yr and 1,900 mt/yr respectively. The load then declines to a low of 790 mt/yr in 1977, and then increases to 970 mt/yr for water year 1978.

The soluble ortho phosphorus loads to Lake Huron vary from 460 mt/yr in 1975 to a high of 840 mt/yr in 1976. Water years 1977 and 1978 have identical values of 370 mt/yr.

The suspended solids loadings from U.S. Lake Huron tributaries showed dramatic fluctuations. The 1976 water year value of 760,000 mt/yr represents a high for the four years examined. This declines to a low of 260,000 mt/yr in 1977, a drop of 500,000 mt/yr.

The chloride loadings fluctuate in much the same manner as the suspended solids. 1976 has the highest value, of 420,000 mt/yr, and 1977 has the lowest value, 200,000 mt/yr.

Lake Erie

Data were not complete for water year 1978 so the analysis for this lake is limited to three years. The total phosphorus loadings from U.S. tributaries to Lake Erie show a steady decline from 1975 through 1977. A high of 8,700 mt/yr in 1975 is 2,600 mt/yr greater than the low value reported in 1977. This is primarily due to a reduction in flow between those years as seen in Table 7.

Soluble ortho phosphorus loads are virtually identical for water year 1975 and 1976. The 1977 value is about 800 mt/yr less at 1,300 mt/yr.

A significant decline in suspended solids is noted from 1975 through 1977. The high value of 6,000,000 mt/yr is the highest observed to any lake from the U.S. side in 1975. The low value of 3,000,000 mt/yr in 1977 is half of the 1975 value but still stands out as the highest load to any one lake.

Chloride loading to Lake Erie is much more stable, with a high value of 860,000 metric tons in 1975, 700,000 metric tons in 1976 and a low of 600,000 metric tons in 1977.

Lake Ontario

Lake Ontario shows higher than average flows for the period of 1975 through 1978. While most lakes were receiving extremely low flows in 1977, Lake Ontario values remained above average. It is interesting to note that there is a significant rise in total phosphorus between 1975 and 1976 from 2,000 mt/yr to 3,500 mt/yr. A significant decline to 1,800 mt/yr occurred during water year 1977. This rise and fall corresponds to the fluctuations in flow over these three years (See Table 7). However, in 1978 the tributary flow is at a level similar to that of 1976 but the total phosphorus load remained relatively low at 2,000 mt/yr.

The soluble ortho phosphorus load for water years 1975, 1976 and 1978 are all around 500 mt/yr. In 1977 however, a load of 700 mt/yr was calculated during a time when flows were low.

The suspended solids load follows the pattern described for total phosphorus. A high is reported in 1976 and a low value reported in 1978.

The chloride load follows the pattern for flow seen in Table 7. 1975 and 1977 are very similar at about 1,200,000 mt/yr. 1976 has a high value of 1,600,000 mt/yr with 1978 at 1,500,000 mt/yr.

Historical Perspective

There is a great danger in attaching significance to any one year of tributary load data because of the natural variability in flow and diffuse source runoff. A long range perspective is needed to evaluate a remedial program or to understand the significance of tributary imputs to the Great Lakes System.

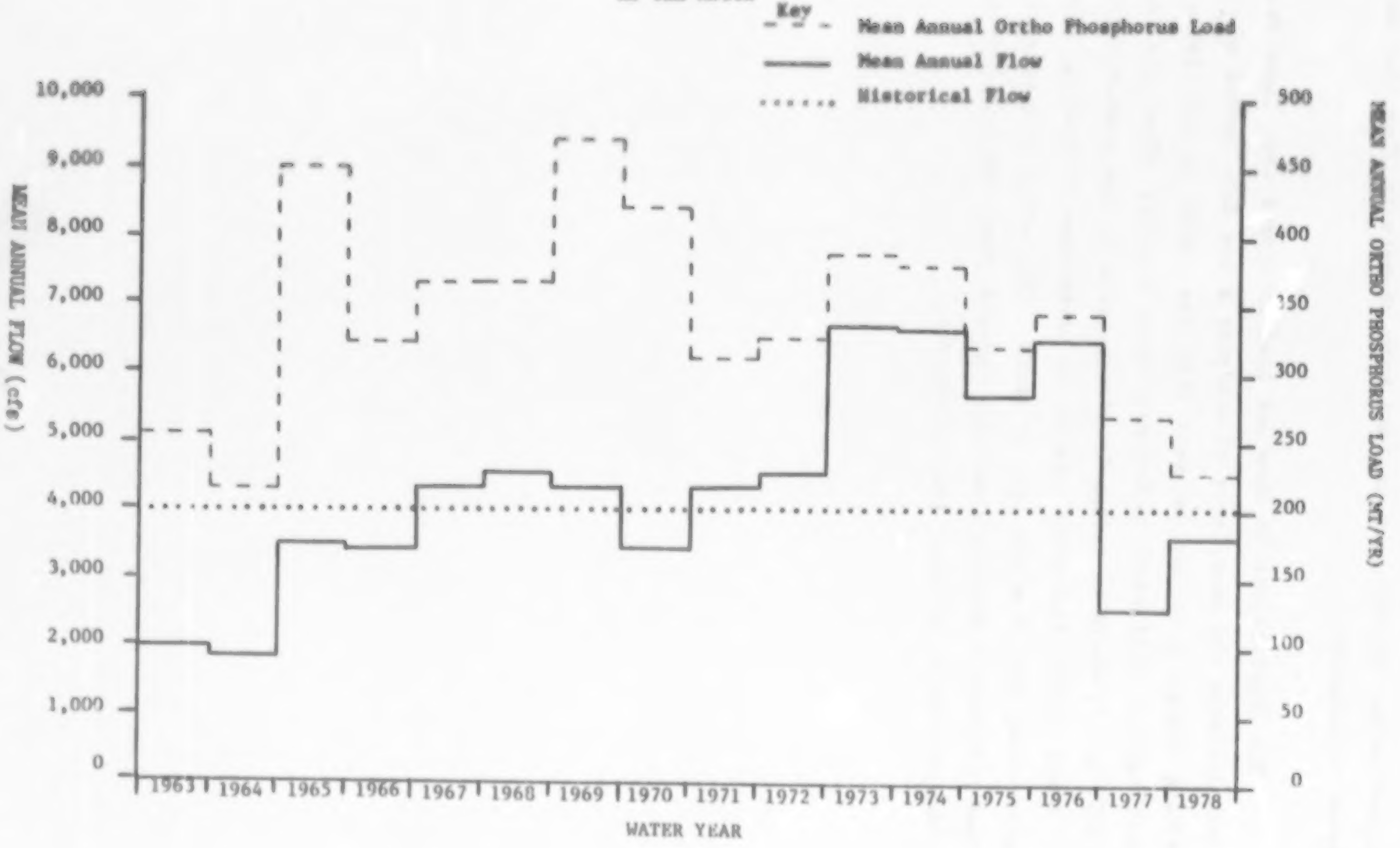
Table 7 illustrates fluctuations in flow over a four-year period. The impact on the loads can be seen more clearly by adjusting the river mouth loads to the historical flow. By applying the proper conversion factors an average concentration to the lake from all U.S. tributaries can be calculated. The values obtained are 0.15 mg/yr. for 1975, 0.13 mg/yr for 1976, 1977, and 1978. Although this only represents four years of data, the average tributary concentration remains remarkably stable over this period of time. In other words, it appears that the natural variability in runoff explains major variations in the loading of total phosphorus to the lakes.

Figure 2 shows the fluctuation in flow at the mouth of the Grand River in Michigan as compared to fluctuations in the annual ortho phosphorus load. Again, an indication of the significance of the flow and load relationship is seen. This detailed look shows the general decline in the ortho phosphorus loads over time from the 1960's to 1970's.

Summary

Lake Erie continues to receive the largest total phosphorus and ortho phosphorus loads while Lake Superior receives the smallest loads. The Maumee River contributes the largest total phosphorus, ortho phosphorus and suspended solid loads from any one stream, while the Oswago River, in the Lake Ontario basin, contributes the largest chloride load. Suspended solids loads remain 90 - 100% nonpoint in nature, while total phosphorus varies from 40 - 80% nonpoint. The highest unit area loads of total phosphorus and suspended solids are in the Lake Erie basin, the "thumb" area of Michigan, and in western Lake Ontario. Almost all the point sources of phosphorus are from municipal plants, with the industrial component being low overall.

FIGURE 2
GRAND RIVER, MICHIGAN
FLOW AND ORTHO PHOSPHORUS LOAD
AT THE MOUTH



There are significant differences in tributary response to precipitation. This is evidenced by examining the 1976 and 1977 water years. Event response tributaries (as defined in Sonzogni et al., 1978) show much wider fluctuations in load with changes in flow then do stable response tributaries.

The fluctuations in flow and load monitored over these four years of data indicate the importance of studying a low flow period of time. By examining Figure 1 it can be seen that the early to mid-1960's have a significantly different tributary flow history than the early to mid-1970's. It would be extremely advantageous to the understanding of the U.S. Great Lakes tributary system to undertake a loading calculation program using data from the last 20 years. This would give some indication of how tributary concentrations have changed over time, particularly with the implementation of point source controls.

CHAPTER 4

POST-PLUARG MEETING ON POLLUTION ABATEMENT STRATEGIES FOR THE GREAT LAKES

A meeting was held on June 24th and 25th, 1980, to assess technical developments which have occurred since the completion of PLUARG. Co-sponsored by the GLBC and the Great Lakes National Program Office of the U.S. Environmental Protection Agency, the participants included representatives from federal, provincial, and state government agencies as well as representatives from "208" areawide water quality management agencies and academic experts from both the U.S. and Canada. The group included representatives from nonpoint pollution control projects and programs underway in the basin as well as a number of the members of the Task C Reference Group of PLUARG.

The objectives of the meeting were to:

1. reevaluate the Pollution from Land Use Activities Reference Group findings and recommendations in light of recent developments;

2. consider the International Joint Commission's conclusions and recommendations contained in its report to the governments of the U.S. and Canada;

3. identify future research and program needs;

4. reinforce the technical contacts established during the PLUARG study;

5. provide the Great Lakes National Program Office with information on the progress that has been made toward understanding nonpoint source pollution since PLUARG's final report, and to identify additional information needs.

The conference focused on providing answers, or at least statements, in reply to a series of questions developed by Great Lakes Basin Commission staff. The questions reflected the PLUARG findings and recommendations, recommendations contained in the IJC's report to the governments, and perceived information needs relating to nonpoint source pollution. Major conclusions and recommendations were as follows:

1. Probably more progress has been made toward understanding nonpoint source pollution problems in the Great Lakes basin than any place else in the world. Results and recommendations from past and continuing programs in both the U.S. and Canada (i.e., PLUARG, 108(a) Demonstration Projects such as the Black Creek Study and the Washington County Project, the Wisconsin Fund, "208" Studies, the Lake Erie Wastewater Management Study, etc.) seem to be converging. However, with the completion of PLUARG, no formal mechanism remains for coordination and unified action.

2. The IJC's recommendation of regulation of manure spreading on frozen ground, as highlighted in its report to the governments on pollution from land runoff, does not reflect the work done on this subject in PLUARG and is not appropriate.

3. There is still no indication that lead is causing water quality problems in the Great Lakes. The statement in the IJC's report to the governments that lead is a "pollution time bomb" is unfounded and not in accord with the PLUARG report.

4. Additional promotion and consideration should be given to the other benefits of nonpoint source controls (besides phosphorus load reductions) such as energy savings and reductions in heavy metal loadings. Negative secondary effects that may occur as a result of remedial programs should also be considered in development of a Great Lakes management strategy.

5. It is recommended that studies designed to provide detailed cost information on agricultural nonpoint controls be stepped up.

6. Now more than ever, a need exists for coordinating the efforts of "208" agency programs and ongoing federal and state demonstration projects and programs to assure consistency in the recommendations made to the public concerning nonpoint source pollution control.

7. Continued monitoring is necessary to establish whether the load reductions (including available phosphorus) expected from different remedial programs actually occur. Event monitoring (including measurement of available P) is also needed on select tributaries to determine the effectiveness of nonpoint controls during major storm events.

8. Little is known about the long-term effects of nonpoint controls. There is a need for adequately funded, long-term demonstration programs.

9. Studies should be encouraged on the percentage of pollutants contained in urban and rural runoff which are attributable to atmospheric deposition.

10. With regard to P availability: over the long run, the majority of point source phosphorus which reaches the lakes is in a biologically available form.

11. PLUARG recommended that "hydrologically active areas" be identified at the local level. While the hydrologically active area concept is still valid, it needs further definition if it is to be practically applied. Techniques and guidelines should be developed for identification of hydrologically active areas (remote sensing offers some promise).

12. Acceptance of conservation tillage is rapidly increasing in many parts of the U.S. and Canadian basins. This is largely due to the energy savings realized with conservation tillage and the effort which has been made to demonstrate the utility of the method to farmers. The importance of a long-term, person-to-person technology transfer program should not be underestimated (GLBC, 1980a).

An expanded summary of the meeting is contained in Appendix D.

CHAPTER 5

"WATERSHED"
A MANAGEMENT TECHNIQUE FOR CHOOSING AMONG POINT AND NONPOINT CONTROL STRATEGIES

As part of its Post-PLUARG work effort for EPA, GLBC staff began development of a management technique designed to aid water quality planners evaluate sources and controls of a given pollutant within a basin. The management technique, "WATERSHED", is basically an accounting technique to help assimilate existing state-of-the-art information so that reasonable choices among pollution control alternatives can be made. It provides a logical sequence for estimating the relative importance of different pollutant inputs at the river mouth or some receiving body. WATERSHED is unique in that it integrates the vast amount of technical information now available on both point and non-point pollution control. It attempts to quantify information generated from years of research and demonstration.

WATERSHED has been derived from several studies, most conducted in the Great Lakes basin. These studies include the Pollution from Land Use Activities Reference Group study, the Lake Erie Wastewater Management Study, the Black Creek, Washington County, and Red Clay Erosion Demonstration projects conducted under Section 108 of Public Law 92-500, a host of studies conducted under Section 208 of Public Law 92-500, and the Wisconsin Fund Program.

However, although all of the above studies have had an influence, the foundation for WATERSHED lies in the "overview modeling" process (Johnson et al., 1978; Heidtke, 1978; Heidtke et al., 1979) developed as part of the PLUARG study. Yet, WATERSHED is designed to be much more flexible than PLUARG's overview model. While the overview model was basically a research tool, WATERSHED is designed as a management or application tool. Appendix E contains a synopsis of the WATERSHED process.

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APPENDIX A

HONEY CREEK WATERSHED MANAGEMENT PROJECT TOUR - JULY 16, 1980

The Honey Creek Watershed Management Project to study the economic and water quality implications of no-till farming is in its second year of operation. This tour of several demonstration plots of corn grown under no-till conditions was conducted to provide a "hands on" experience for a group of Canadians interested in the applicability of no-till for Ontario farmers. An earlier tour of the project was held in October, 1979 (see Sullivan *et al.*, 1980). Information made available since that date has been summarized below.

SOIL TYPE

Soil drainage is a key factor in determining whether or not no-till farming is feasible. The Honey Creek Watershed soils fall in the moderately well to somewhat poorly drained range. Blount silt loam is the most common soil type. In many areas, particularly low-lying regions, some surface and sub-surface drainage is required for no-till to be successful. However, it was emphasized that in these areas, additional drainage would be needed to practice conventional tillage as well.

NITROGEN FERTILIZER USE

Conflicting results exist with regard to the effect of no-till on nitrogen fertilizer use. In several of the Honey Creek demonstra-tions plots nitrogen fertilizer use increased. However, this was due to increased soil moisture content which created the potential for larger yields.

The use of rye as a cover crop may increase denitrification. One farmer whose corn crop exhibited signs of nitrogen deficiency early in its growth traced the problem to a combination of wet soil and a rye cover crop. When "burned off", the rye utilized much of the available nitrogen as it decomposed.

NO-TILL PLANTERS

No-till farming uses a planter which performs several operations in one. The planter also has the flexibility to be used under conventional tillage settings with very successful results. The no-till planter is $200 to $300 per row more expensive than a conven-tional planter. An Allis-Chalmers six row no-till planter costs roughly $12,000.

The most important aspects of a planter are to provide consistent and accurate seed depth and good seed-soil contact. No-till planters have improved over the years with innovations such as the press wheel which performs the final operation of pressing the soil down over the seed to ensure good contact with the soil.

There is an increasing demand for no-till planters in the Honey Creek watershed and availability is still a problem. One farmer cited a waiting period of two years for a John Deer no-till planter. Technical assistance is required to familiarize the farmer with calibrating the planter to the proper seed depth.

INSECT CONTROL

Both the project conservationist and a cooperative extension agent stated that increased insecticide use was not of necessity with no-till. Keeping chemical use to a minimum requires that the farmer be provided with technical assistance. An example of this is a cooperative extension service program providing weekly inspections for insects at a nominal fee. It was repeatedly emphasized that a high level of management is the key to ensuring the most efficient and effective use of insecticide.

WATER QUALITY

Part of the tour consisted of a visit to the River Studies Lab of Heidelberg College under the direction of Dr. David Baker. Dr. Baker noted that no-till has the potential to reduce phosphorus loadings to streams. This is accomplished through a reduction in soil erosion and increased rainfall infiltration which allows phosphorus to be adsorbed in lower parts of the soil profile.

The issue of the delivery ratio of sediment to streams is being studied. Results so far indicate a range from 6% to 12% depending upon soil type. No correlation between watershed size and delivery ratio has been found thus far.

Studies are just beginning to determine the level of herbicide present in water bodies. Atrazine is being examined, with higher levels being detected then expected. However, these results are tentative and no explanation has been attempted as yet.

NO-TILL APPLICABILITY IN NORTHERN REGIONS

It was emphasized to the Canadian visitors that the climatic and soil conditions present in Ontario might make no-till farming unfeasible. Similar conditions exist in the northern portion of the U.S. Great Lakes basin. The positive effects of a layer of mulch on the soil surface increases further south by keeping the soil moister and cooler in the spring. In northern areas, less extreme methods of residue management, ie., other conservation tillage practices, would be more applicable to meeting the goals of reducing soil erosion, improving water quality and reducing farmer expenses.

APPENDIX B

GLBC "208" BIBLIOGRAPHY RETRIEVAL

The following is a sample of a retrieval made from the GLBC "208" Bibliography discussed in Chapter 2. The key words chosen for this example were nonpoint source "problems" (key word #210), "remedial measures" (key word #220), and "costs" (key word #260). The format selected for this sample retrieval included specification of the 208 agency acronym, state of location, applicable lake basin(s) and the title and date of the report.

208 RETRIEVAL FOR NONPOINT SOURCES:
PROBLEMS, REMEDIAL MEASURES, COSTS

STATE: Minnesota
LAKE(S): Superior
208 AGENCY: MPCA

Forestry. Package 1. August, 1979.

STATE: Minnesota
LAKE(S): Superior
208 AGENCY: MPCA

Construction Activities. Package 1. August, 1978.

STATE: Minnesota
LAKE(S): Superior
208 agency: MPCA

Highway De-icing Chemicals. Package 1, Supplement. June, 1978.

STATE: Minnesota
LAKE(S): Superior
208 AGENCY: MPCA

Highway De-Icing Chemicals. Package 2. May, 1978.

STATE: Minnesota
LAKE(S): Superior
208 AGENCY: MPCA

Urban Runoff. Package 1. May, 1978.

STATE: Minnesota
LAKE(S): Superior
208 AGENCY: MPCA

Urban Runoff. Package 2, Supplement to: Descriptions of Existing Institutions and Programs Related to Water Quality Management Planning Study Topics. November, 1978.

STATE: Minnesota
LAKE(S): Superior
208 AGENCY: MPCA

Roadside Erosion. Package 2, Supplement to: Description of Existing Institutions and Programs Related to Water Quality Management Planning Study Topics. January, 1979.

STATE: Wisconsin
LAKE(S): Michigan
208 AGENCY: WDNR

Upper Fox River Basin Water Quality Management Plan. Appendix D: Nonpoint Source Information. 1977.

STATE: Wisconsin
LAKE(S): Michigan
208 AGENCY: FVWQPA

Report No. 5: Instream Alteration Study. October, 1977.

STATE: Illinois
LAKE(S): Michigan
208 AGENCY: NIPC

Areawide Water Quality Management Plan Part I Chapters 1-10. June, 1978.

STATE: Illinois
LAKE(S): Michigan
208 AGENCY: NIPC

Areawide Water Quality Management Plan, Summary. (Adopted by Northeastern Illinois Planning Commission, January 4, 1979). March, 1979.

STATE: Indiana
LAKE(S): Michigan
208 AGENCY: MACOG

Plate Book. 1978.

STATE: Michigan
LAKE(S): Huron
208 AGENCY: ECMPDR

Development of Management Alternatives: Control of Pollution from Individual Waste Treatment Systems (Preliminary Draft). July, 1977.

STATE: Michigan
LAKE(S): Huron
208 AGENCY: ECMPDR

Nonpoint Source Inventory. Region VII Areawide Waste Treatment Management Study (Preliminary Draft). 1977.

STATE: Michigan
LAKE(S): Huron
208 AGENCY: ECMPDR

Water Quality Relationships. Vol. IA, IB, II (Preliminary Draft). Region VII Areawide Waste Treatment Management Study. February, 1978.

STATE: Michigan
LAKE(S): Huron
208 AGENCY: ECMPDR

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STATE: Michigan
LAKE(S): Huron
208 AGENCY: ECMPDR

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STATE: Michigan
LAKE(S): Huron
208 AGENCY: ECMPDR

Selected 208 Plan and Plan Management Program (Preliminary Draft). Region VII Areawide Waste Treatment Management Study. June, 1978.

STATE: Michigan
LAKE(S): Huron Erie
208 AGENCY: GLS-V

Urban Nonpoint Source Pollution in GLS Region V - A Background Report (First Draft). February, 1978.

STATE: Michigan
LAKE(S): Huron Erie
208 AGENCY: GLS-V

208 Areawide Water Quality Plan. Volume I - Plan Summary (Draft). May, 1978 (Revised, August, 1978).

STATE: Michigan
LAKE(S): Huron Erie
208 AGENCY: GLS-V

Urban Nonpoint Source Pollution in GLS Region V - A Background Report (Draft). April, 1978.

STATE: Michigan
LAKE(S): Huron Erie
208 AGENCY: GLS-V

Agricultural Nonpoint Source Pollution in GLS Region V - A Background Report (Draft). April, 1978.

STATE: Michigan
LAKE(S): Huron Erie
208 AGENCY: GLS-V

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208 AGENCY: GLS-V

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STATE: Michigan
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208 AGENCY: GLS-V

Residual Wastes and Water Quality in Region V - A Background Report. April, 1978.

STATE: Michigan
LAKE(S): Huron Erie
208 AGENCY: GLS-V

Solid Waste. April, 1978

STATE: Michigan
LAKE(S): Huron
208 AGENCY: NEMCOG

Appendices 1-9: Working Papers of the Clean Water Program. 1978.

STATE: Michigan
LAKE(S): Huron
208 AGENCY: NEMCOG

Draft Working Papers of the Clean Water Program. 1978.

STATE: Michigan
LAKE(S): Michigan Huron
208 AGENCY: NMRPDC

Water Quality Assessment. January, 1978.

STATE: Michigan
LAKE(S): Michigan Huron
208 AGENCY: NMRPDC

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STATE: Michigan
LAKE(S): Michigan Erie
208 AGENCY: Reg II

Selected 208 Plan. December, 1977 (Revised, April, 1978).

STATE: Michigan
LAKE(S): Michigan Erie
208 AGENCY: Reg II

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STATE: Illinois
LAKE(S): Michigan
208 AGENCY: NIPC

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STATE: New York
LAKE(S): Ontario
208 AGENCY: NYSDEC

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STATE: New York
LAKE(S): Erie Ontario
208 AGENCY: NYSDEC

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STATE: New York
LAKE(S): Ontario Erie
208 AGENCY: NYSDEC

New York State Non-Designated 208 Urban Runoff Study. First Interim Report. Synopsis.

STATE: New York
LAKE(S): Ontario
208 AGENCY: CNYRPDB

Nonpoint Sources of Pollution. Interim Report. November 1976.

STATE: New York
LAKE(S): Erie Ontario
208 AGENCY: ENCRPB

Rural Nonpoint Runoff Problems/Analysis. Task 10. Final. January, 1979.

STATE: New York
LAKE(S): Erie Ontario
208 AGENCY: ENCRPB

Urban Storm Runoff Problems/Analysis. Task 9. Final. January, 1979.

STATE: Wisconsin
LAKE(S): Michigan
208 AGENCY: SEWRPC

Technical Report #21: Sources of Pollution in Southeastern Wisconsin: 1975. September, 1978.

STATE: Wisconsin
LAKE(S): Michigan
208 AGENCY: SEWRPC

Vol. 4: Rural Stormwater Runoff. December, 1976.

STATE: Wisconsin
LAKE(S): Michigan
208 AGENCY: SEWRPC

Vol. 3: Urban Stormwater Runoff. July, 1977.

STATE: Wisconsin
LAKE(S): Superior
208 AGENCY: WDNR

Appendix C: Communities with Septic Tank Problems.

STATE: Ohio
LAKE(S): Erie
208 AGENCY: TMACOG

208 Report #17: Technical Alternatives for On-Site Wastewater Treatment and Disposal. September, 1976.

STATE: Ohio
LAKE(S): Erie
208 AGENCY: TMACOG

208 Report #13: Legal Authority for Agricultural Pollution Abatement Programs in Ohio. January, 1976.

STATE: Ohio
LAKE(S): Erie
208 AGENCY: TMACOG

Proceedings of Workshop on Agricultural Practices for the Abatement of Nonpoint Sources of Water Pollution. June, 1976. Final Draft of Institutional Arrangements for Agricultural Pollution Abatement.

STATE: Ohio
LAKE(S): Erie
208 AGENCY: NOACA

Agricultural and Urban Sediment Pollution Abatement in Northeastern Ohio. 1977.

STATE: Ohio
LAKE(S): Erie
208 AGENCY: NOACA

Road Salt: Profile of Environmental and Property Impacts. May 1978.

STATE: Ohio
LAKE(S): Erie
208 AGENCY: NOACA

Urban Stormwater Runoff

STATE: Ohio
LAKE(S): Erie
208 AGENCY: NOACA

Control of Nonpoint Source Pollution from Rural Lands Through the Use of Best Management Practices.

STATE: Ohio
LAKE(S): Erie
208 AGENCY: EDATA

208 Areawide Waste Treatment Management Plan for Mahoning and Trumbull Counties. Final, July, 1977. Volume III: Stormwater Pollution Control.

STATE: New York
LAKE(S): Erie Ontario
208 AGENCY: ENCRPB

Pollutant Accumulation and Sedimentation Problems/Analysis. Task 15. Final. January, 1979.

APPENDIX C

1976 - 1978 RIVER MOUTH LOADINGS

The following are the results of the loadings calculations described in Chapter 3. Information given is for water years 1976, 1977 and 1978. Information is presented by tributary and the associated lake basin and river group (as explained in Chapter 3). The load is presented in metric tons per year (mt/yr) followed by the mean square error (in mt/yr) squared. Finally, the number of samples utilized to calculate the load is specified.

```
                          TOTAL PHOSPHORUS 1976
            TRIBUTARY     LAKE  RIVER           LOAD       MEAN SQUARE       NUM OF
             NAME         BASIN GROUP           MT\YR     ERR(MT\YR)**2     SAMPLES

       1     PINE         ERIE   1              76.5            1819.7        12
  >    2     BELLE        ERIE   1              33.2              76.8        12
  >    3     CLINTON      ERIE   1             156.2             405.3        12
  >    4     RAISIN       ERIE   1             269.2           13049.2        12
  >    5     MAUMEE       ERIE   2            2960.0
  >    6     PORTAGE      ERIE   2              86.5
  >    7     SANDUSKY     ERIE   2             362.0                   NA
  >    8     HURON OHIO   ERIE   2              92.1
  >    9     VERMILION    ERIE   2              22.2               0.2        10
  >   10     BLACK        ERIE   3              34.5               9.9        10
  >   11     CUYAHOGA     ERIE   3             416.5            3244.6        13
  >   12     CHAGRIN      ERIE   3              43.6              13.5        11
  >   13     GRAND OH     ERIE   3             209.8           19334.8        12
  >   14     ASHTABULA    ERIE   3              17.7               3.9        12
  >   15     CONNEAUT     ERIE   3              31.5               0.2        11
```

SOLUBLE ORTHO PHOSPHORUS 1976

		TRIBUTARY NAME	LAKE BASIN	RIVER GROUP	LOAD MT\YR	MEAN SQUARE ERR(MT\YR)**2	NUM OF SAMPLES
	1	PINE	ERIE	1	32.6	371.1	12
>	2	BELLE	ERIE	1	14.2	3.0	12
>	3	RAISIN	ERIE	1	85.6	312.6	12
>	4	MAUMEE	ERIE	2	598.0		
>	5	PORTAGE	ERIE	2	30.5	NA	
>	6	HURON OHIO	ERIE	2	33.4		
>	7	VERMILION	ERIE	2	5.3	3.2	10
>	8	SANDUSKY	ERIE	2	68.6		
>	9	GRAND OH	ERIE	3	80.2	438.0	5

SUSPENDED SOLIDS 1976

```
          TRIBUTARY     LAKE   RIVER         LOAD      MEAN SQUARE      NUM OF
            NAME        BASIN  GROUP        MT\YR     ERR(MT\YR)**2    SAMPLES

     1     PINE         ERIE     1         29566.5      265076544.0      12
>    2     BELLE        ERIE     1         16281.2       52774256.0      12
>    3     CLINTON      ERIE     1        383316.7    30985809920.0      11
>    4     RAISIN       ERIE     1        148098.3    11191005184.0      12
>    5     MAUMEE       ERIE     2       1740000.0
>    6     PORTAGE      ERIE     2         27100.0
>    7     SANDUSKY     ERIE     2        182000.0                   NA
>    8     HURON        ERIE     2         55800.0
>    9     VERMILION    ERIE     2         14533.2       92366512.0      11
>   10     BLACK        ERIE     3         10702.8        3326045.0       9
>   11     ROCKY        ERIE     3         32081.0              0.0     265
>   12     CUYAHOGA     ERIE     3        133805.3     1038481408.0      12
>   13     CHAGRIN      ERIE     3        379774.0              0.0     160
>   14     GRAND OH     ERIE     3         24393.8      168137008.0      11
>   15     ASHTABULA    ERIE     3          2565.1        1234701.0       9
>   16     CONNEAUT     ERIE     3         24336.2        9366670.0       8
#
#
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CHLORIDE 1976

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>         TRIBUTARY      LAKE  RIVER          LOAD       MEAN SQUARE     NUM OF
>           NAME         BASIN GROUP          MT\YR     ERR(MT\YR)**2   SAMPLES

      1    PINE          ERIE    1         16198.5       72281776.0      12
>     2    BELLE         ERIE    1          4997.1       10847020.0      12
>     3    CLINTON       ERIE    1         44549.0       42210448.0      12
>     4    RAISIN        ERIE    1         20536.7        8652080.0      12
>     5    MAUMEE        ERIE    2        161000.0
>     6    PORTAGE       ERIE    2          1900.0                   NA
>     7    SANDUSKY      ERIE    2         25800.0
>     8    HURON OHIO    ERIE    2          9230.0
>     9    VERMILION     ERIE    2         10149.2       10282868.0      11
>    10    BLACK         ERIE    3         10767.5        1349467.0      10
>    11    CUYAHOGA      ERIE    3        132638.9      427491328.0      13
>    12    CHAGRIN       ERIE    3         20944.2        1867937.0      11
>    13    GRAND OH      ERIE    3        596050.4  110720778240.0      12
>    14    ASHTABULA     ERIE    3          6055.5        3683983.0      12
>    15    CONNEAUT      ERIE    3         83962.9     8327942144.0      10
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TOTAL PHOSPHORUS 1977

		TRIBUTARY NAME	LAKE BASIN	RIVER GROUP	LOAD MT\YR	MEAN SQUARE ERR(MT\YR)**2	NUM OF SAMPLES
	1	ST LOUIS	SUPE	1	70.3	44.0	13
>	2	BOIS BRULE	SUPE	1	9.5	8.7	9
>	3	NEMADJI	SUPE	1	37.2	80.4	23
>	4	BAD	SUPE	1	52.9	308.2	23
>	5	MONTREAL	SUPE	1	34.9	23.0	12
>	6	TAHQUAMENON	SUPE	2	21.2	10.2	24
>	7	PRESQUE ISLE	SUPE	2	5.9	1.6	12
>	8	STURGEON	SUPE	2	37.3	318.0	12
>	9	CARP	SUPE	2	21.1	20.4	8
>	10	ONTONAGAN	SUPE	2	141.1	2667.5	24
>	11	FORD	MICH	1	7.5	2.0	24
>	12	OCONTO	MICH	1	45.6	196.8	11
>	13	SHEBOYGAN	MICH	1	33.4	7.4	11
>	14	PESHTIGO	MICH	1	20.8	3.0	11
>	15	FOX	MICH	1	356.0	1708.0	25
>	16	PENSAUKEE	MICH	1	1.8	0.0	11
>	17	MANITOWOC	MICH	1	18.4	8.6	11
>	18	KEWAUNEE	MICH	1	4.7	0.1	10
>	19	E TWIN	MICH	1	18.0	1.0	11
>	20	ROOT	MICH	2	17.6	14.0	10
>	21	MENOMINEE	MICH	1	50.6	79.6	12
>	22	MILWAUKEE	MICH	2	38.4	31.2	12
>	23	ST JOSEPH	MICH	3	305.1	716.2	12
>	24	KALAMAZOO	MICH	3	173.8	136.6	24
>	25	GRAND	MICH	3	513.3	1094.2	242
>	26	MUSKEGON	MICH	4	38.4	18.9	24
>	27	MANISTEE	MICH	4	50.4	30.8	24
>	28	BOARDMAN	MICH	4	4.0	0.4	12
>	29	*MANISTIQUE	MICH	4	39.5	12.8	24
>	30	WHITEFISH	MICH	4	4.4	1.2	12
>	31	ESCANABA	MICH	4	33.0	24.9	24
>	32	THUNDER BAY	HURO	1	10.8	1.1	12
>	33	RIFLE	HURO	1	13.2	16.9	24
>	34	AU GRES	HURO	1	1.9	0.1	12
>	35	CHEBOYGAN	HURO	1	18.0	9.2	24
>	36	AU SABLE	HURO	1	14.5	4.4	12
>	37	PINE	HURO	1	84.9	1779.1	12
>	38	SAGINAW	HURO	2	510.6	2282.4	36
>	39	BELLE	ERIE	1	5.9		
>	40	BLACK	ERIE	1	31.6		
>	41	CLINTON	ERIE	1	120.0		
>	42	HURON	ERIE	1	29.7		NA
>	43	RAISON	ERIE	1	161.0		
>	44	ROUGE	ERIE	1	203.0		
>	45	MAUMEE	ERIE	2	1700.0		

TOTAL PHOSPHORUS 1977

		TRIBUTARY NAME	LAKE BASIN	RIVER GROUP	LOAD MT\YR	MEAN SQUARE ERR(MT\YR)**2	NUM OF SAMPLES
	46	PORTAGE	ERIE	2	109.0		
>	47	HURON	ERIE	2	111.0		
>	48	SANDUSKY	ERIE	2	244.0		
>	49	VERMILLION	ERIE	2	70.0		
>	50	BLACK	ERIE	3	170.0		
>	51	ROCKY	ERIE	3	127.0		
>	52	CUYUHGA	ERIE	3	357.0		NA
>	53	CHAGRIN	ERIE	3	81.3		
>	54	GRAND	ERIE	3	88.1		
>	55	ASHTABULA	ERIE	3	16.7		
>	56	CONNEAUT	ERIE	4	23.9		
>	57	CATTARAGUS	ERIE	4	252.0		
>	58	18 MILE	ERIE	4	133.0		
>	59	GENESEE	ONTA	1	298.9	2233.0	17
>	60	OSWEGO	ONTA	2	799.4	71146.0	22
>	61	BLACK NY	ONTA	3	146.0	167.7	21
>	62	RAQUETTE	ONTA	3	91.1	435.0	8
>	63	GRASS	ONTA	3	78.1	129.2	8
>	64	OSWEGATCHIE	ONTA	3	69.0	260.8	8

SOLUBLE ORTHO PHOSPHORUS 1977

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>       TRIBUTARY      LAKE  RIVER       LOAD       MEAN SQUARE      NUM OF
>         NAME         BASIN GROUP      MT\YR     ERR(MT\YR)**2     SAMPLES

      1     ST LOUIS    SUPE   1          17.2            136.6        4
>     2     BOIS BRULE  SUPE   1           3.3              0.2        9
>     3     NEMADJI     SUPE   1           3.5              0.5       10
>     4     BAD         SUPE   1          15.9            213.8       10
>     5     MONTREAL WISSUPE   1           4.2              0.9        9
>     6     TAHQUAMENON SUPE   2           2.6              0.9       12
>     7     ONTONAGAN   SUPE   2          17.1              5.8       12
>     8     PRESQUE ISLESUPE   2           0.8              0.0       12
>     9     STURGEON    SUPE   2           2.5              0.2       12
>    10     CARP        SUPE   2          13.5             17.7        8
>    11     OCONTO      MICH   1          10.0             83.5       11
>    12     PESHTIGO    MICH   1           5.0              4.3       11
>    13     FOX         MICH   1          69.6            227.2       12
>    14     PENSAUKEE   MICH   1           0.5              0.0       11
>    15     MANITOWOC   MICH   1           7.2             13.4       11
>    16     KEWAUNEE    MICH   1          10.7             19.5       10
>    17     E TWIN      MICH   1           8.0              0.6       11
>    18     SHEBOYGAN   MICH   1          13.5             18.8       11
>    19     ROOT        MICH   2           6.7             14.7       10
>    20     MENOMINEE   MICH   1           6.6              0.8       12
>    21     ST JOSEPH   MICH   3          61.0            382.4       12
>    22     KALAMAZOO   MICH   3          72.0             39.0       12
>    23     GRAND       MICH   3         268.5            108.5      243
>    24     MUSKEGON    MICH   4           6.5              1.9       12
>    25     MANISTEE    MICH   4          16.2              9.5       12
>    26     BOARDMAN    MICH   4           1.2              0.1       12
>    27     *MANISTIQUE MICH   4           7.2              3.2       12
>    28     WHITEFISH   MICH   4           0.7              0.0       12
>    29     ESCANABA    MICH   4          16.2             36.3       12
>    30     FORD        MICH   1           1.2              1.2       12
>    31     THUNDER BAY HURO   1           2.1              0.3       12
>    32     RIFLE       HURO   1           2.0              0.1       12
>    33     AU GRES     HURO   1           0.6              0.0       12
>    34     CHEBOYGAN   HURO   1           2.0              0.1       12
>    35     AU SABLE    HURO   1           4.5              0.9       12
>    36     PINE        HURO   1           7.1              0.2       12
>    37     SAGINAW     HURO   2         292.4           2589.3       24
>    38     BELLE       ERIE   1           2.7
>    39     BLACK       ERIE   1           9.8
>    40     CLINTON     ERIE   1          59.7
>    41     HURON       ERIE   1           9.6
                                                                  NA
>    42     RAISON      ERIE   1          77.5
>    43     ROUGE       ERIE   1          82.2
>    44     MAUMEE      ERIE   2         348.0
>    45     PORTAGE     ERIE   2          38.1
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SOLUBLE ORTHO PHOSPHORUS 1977

		TRIBUTARY NAME	LAKE BASIN	RIVER GROUP	LOAD MT\YR	MEAN SQUARE ERR(MT\YR)**2	NUM OF SAMPLES
	46	HURON	ERIE	2	24.9		
>	47	SANDUSKY	ERIE	2	59.8		
>	48	VERMILLION	ERIE	2	19.9		
>	49	BLACK	ERIE	3	69.4		
>	50	ROCKY	ERIE	3	52.7		
>	51	CUYUHGA	ERIE	3	152.0		
>	52	CHAGRIN	ERIE	3	21.2		
>	53	GRAND	ERIE	3	22.9		
>	54	ASHTABULA	ERIE	3	0.7		
>	55	CONNEAUT	ERIE	4	0.7		
>	56	CATTARAGUS	ERIE	4	3.8		
>	57	18 MILE	ERIE	4	2.9		
>	58	GENESEE	ONTA	1	90.9	237.8	9
>	59	OSWEGO	ONTA	2	428.5	114769.9	10
>	60	BLACK NY	ONTA	3	26.6	78.1	8
>	61	RAQUETTE	ONTA	3	13.5	35.4	7
>	62	GRASS	ONTA	3	28.6	6.7	7
>	63	OSWEGATCHIE	ONTA	3	14.8	17.5	8

CHLORIDE 1977

		TRIBUTARY NAME	LAKE BASIN	RIVER GROUP	LOAD MT\YR	MEAN SQUARE ERR(MT\YR)**2	NUM OF SAMPLES
	1	ST LOUIS	SUPE	1	15616.9	4291579.0	15
>	2	BOIS BRULE	SUPE	1	159.6	1824.1	4
>	3	NEMADJI	SUPE	1	809.5	7919.3	17
>	4	BAD	SUPE	1	1993.5	30237.8	17
>	5	MONTREAL	SUPE	1	5659.4	8128852.0	12
>	6	TAHQUAMENON	SUPE	2	2037.5	163365.9	24
>	7	PRESQUE ISLE	SUPE	2	411.4	9134.4	12
>	8	STURGEON	SUPE	2	1054.5	12579.4	12
>	9	CARP	SUPE	2	922.2	36570.5	8
>	10	ONTONAGAN	SUPE	2	2435.1	72546.3	24
>	11	FORD	MICH	1	552.4	777.2	24
>	12	OCONTO	MICH	1	4759.6	7016444.0	2
>	13	FOX	MICH	1	36054.1	4278481.0	23
>	14	PESHTIGO	MICH	1	2487.1	1083910.0	3
>	15	MANITOWOC	MICH	1	1265.7	242.8	3
>	16	PENSAUKEE	MICH	1	407.8	1391.9	3
>	17	SHEBOYGAN	MICH	1	3402.8	31126.2	11
>	18	KEWAUNEE	MICH	1	662.1	156.9	4
>	19	E TWIN	MICH	1	1649.1	664.1	3
>	20	MENOMINEE	MICH	1	5254.4	51383.3	12
>	21	ROOT	MICH	2	3826.1	10035518.0	13
>	22	MILWAUKEE	MICH	2	10543.2	3275017.0	12
>	23	ST JOSEPH	MICH	3	68252.9	17673472.0	12
>	24	KALAMAZOO	MICH	3	48568.1	4080633.0	24
>	25	GRAND	MICH	3	95561.2	5913592.0	242
>	26	MUSKEGON	MICH	4	35364.2	1124774.0	24
>	27	MANISTEE	MICH	4	74895.2	20602976.0	24
>	28	BOARDMAN	MICH	4	1698.0	3850.0	12
>	29	*MANISTIQUE	MICH	4	2983.9	9303.8	24
>	30	WHITEFISH	MICH	4	916.8	4966.8	12
>	31	ESCANABA	MICH	4	6994.9	3233628.0	24
>	32	THUNDER BAY	HURO	1	3107.2	13758.1	12
>	33	RIFLE	HURO	1	3788.5	27410.9	23
>	34	AU GRES	HURO	1	2465.1	124232.8	12
>	35	CHEBOYGAN	HURO	1	5197.5	24485.3	24
>	36	AU SABLE	HURO	1	6900.1	32722.9	12
>	37	PINE	HURO	1	509.7	53371.8	12
>	38	SAGINAW	HURO	2	156433.6	326451456.0	36
>	39	BELLE	ERIE	1	2900.0		NA
>	40	BLACK	ERIE	1	5620.0		
>	41	CLINTON	ERIE	1	56100.0		
>	42	HURON	ERIE	1	22700.0		
>	43	RAISON	ERIE	1	18300.0		
>	44	ROUGE	ERIE	1	73700.0		
>	45	MAUMEE	ERIE	2	123000.0		

CHLORIDE 1977

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>   1      TRIBUTARY     LAKE  RIVER        LOAD       MEAN SQUARE      NUM OF
>   2        NAME        BASIN GROUP        MT\YR     ERR(MT\YR)**2     SAMPLES

            COMMAND
    46      PORTAGE      ERIE   2         13200.0
>   47      HURON        ERIE   2
>   48      SANDUSKY     ERIE   2         29400.0
>   49      VERMILLION   ERIE   2          5400.0
>   50      BLACK        ERIE   3         12100.0
>   51      ROCKY        ERIE   3         10800.0                     NA
>   52      CUYUHGA      ERIE   3         71000.0
>   53      CHAGRIN      ERIE   3         15900.0
>   54      GRAND        ERIE   3         17580.0
>   55      ASHTABULA    ERIE   3          3050.0
>   56      CONNEAUT     ERIE   4          4720.0
>   57      CATTARAGUS   ERIE   4          8100.0
>   58      18 MILE      ERIE   4          2900.0
>   59      GENESEE      ONTA   1        141060.0      245217968.0     17
>   60      OSWEGO       ONTA   2        965441.2     8674615296.0     23
>   61      BLACK NY     ONTA   3         10050.5         378230.4     21
>   62      RAQUETTE     ONTA   3          3106.1          40695.0      8
>   63      GRASS        ONTA   3          4131.3         266603.0      8
>   64      OSWEGATCHIE  ONTA   3          5738.6         218398.8      8
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SUSPENDED SOLIDS 1977

		TRIBUTARY NAME	LAKE BASIN	RIVER GROUP	LOAD MT\YR	MEAN SQUARE ERR(MT\YR)**2	NUM OF SAMPLES
	1	ST LOUIS	SUPE	1	9089.7	1948354.0	12
>	2	BOIS BRULE	SUPE	1	2063.6	83040.6	11
>	3	BAD	SUPE	1	42851.0	835567872.0	24
>	4	NEMADJI	SUPE	1	62033.4	1.0	365
>	5	MONTREAL	SUPE	1	1185.1	89920.0	12
>	6	TAHQUAMENON	SUPE	2	20875.6	72768160.0	24
>	7	PRESQUE ISLE	SUPE	2	1079.9	212137.1	12
>	8	STURGEON	SUPE	2	40503.2	672361472.0	12
>	9	CARP	SUPE	2	483.8	36500.6	8
>	10	ONTONAGAN	SUPE	2	217354.5	6751281152.0	24
>	11	FORD	MICH	1	2313.1	202748.8	24
>	12	OCONTO	MICH	1	7690.8	11942845.0	11
>	13	PESHTIGO	MICH	1	3506.9	1544790.0	11
>	14	FOX	MICH	1	46105.8	50877792.0	25
>	15	PENSAUKEE	MICH	1	214.7	6347.7	11
>	16	MANITOWOC	MICH	1	1464.9	24563.6	11
>	17	KEWAUNEE	MICH	1	544.3	15974.4	10
>	18	E TWIN	MICH	1	1943.6	21974.4	11
>	19	SHEBOYGAN	MICH	1	4334.8	1090685.0	11
>	20	MENOMINEE	MICH	1	7275.4	1492029.0	12
>	21	ROOT	MICH	2	4762.2	9028218.0	12
>	22	MILWAUKEE	MICH	2	7764.4	25814880.0	12
>	23	ST JOSEPH	MICH	3	68767.9	181685968.0	12
>	24	KALAMAZOO	MICH	3	23008.2	6343270.0	24
>	25	GRAND	MICH	3	47046.9	8685259.0	242
>	26	MUSKEGON	MICH	4	15583.7	29611104.0	24
>	27	MANISTEE	MICH	4	12903.0	2009144.0	24
>	28	BOARDMAN	MICH	4	483.3	9383.2	12
>	29	*MANISTIQUE	MICH	4	10855.1	7513681.0	24
>	30	WHITEFISH	MICH	4	2131.6	404750.7	12
>	31	ESCANABA	MICH	4	3382.1	185289.4	24
>	32	THUNDER BAY	HURO	1	2548.7	295204.1	12
>	33	RIFLE	HURO	1	5807.2	1185211.0	24
>	34	AU GRES	HURO	1	1168.1	63280.9	12
>	35	CHEBOYGAN	HURO	1	4331.3	770389.8	23
>	36	AU SABLE	HURO	1	2735.2	259207.5	12
>	37	PINE	HURO	1	114697.8	3859277312.0	12
>	38	SAGINAW	HURO	2	64408.5	149306144.0	36
>	39	BELLE	ERIE	1	1040.0		
>	40	BLACK	ERIE	1	9290.0		
>	41	CLINTON	ERIE	1	29900.0		
>	42	HURON	ERIE	1	6460.0		
>	43	RAISON	ERIE	1	42200.0		NA
>	44	ROUGE	ERIE	1	57700.0		
>	45	MAUMEE	ERIE	2	803000.0		

SUSPENDED SOLIDS 1977

		TRIBUTARY NAME	LAKE BASIN	RIVER GROUP	LOAD MT\YR	MEAN SQUARE ERR(MT\YR)**2	NUM OF SAMPLES
	46	PORTAGE	ERIE	2	37700.0		
>	47	HURON	ERIE	2	67400.0		
>	48	SANDUSKY	ERIE	2	101000.0		
>	49	VERMILLION	ERIE	2	54600.0		
>	50	BLACK	ERIE	3	115000.0		
>	51	ROCKY	ERIE	3	53700.0		
>	52	CUYUHGA	ERIE	3	117000.0		
>	53	CHAGRIN	ERIE	3	97500.0		
>	54	GRAND	ERIE	3	69300.0		NA
>	55	ASHTABULA	ERIE	3	13500.0		
>	56	CONNEAUT	ERIE	4	23700.0		
>	57	CATTARAGUS	EREI	4	459500.0		
>	58	18 MILE	ERIE	4	190000.0		
>	59	GENESEE	ONTA	1	1048073.0	1.0	365
>	60	OSWEGO	ONTA	2	85778.8	286345472.0	16
>	61	BLACK NY	ONTA	3	24756.8	10119396.0	15
>	62	RAQUETTE	ONTA	3	4693.8	1426200.0	8
>	63	GRASS	ONTA	3	3853.2	85489.8	8
>	64	OSWEGATCHIE	ONTA	3	11446.0	731309.7	8

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                 TOTAL PHOSPHORUS 1978

             TRIBUTARY    LAKE  RIVER        LOAD     MEAN SQUARE     NUM OF
               NAME       BASIN GROUP       MT\YR   ERR(MT\YR)**2    SAMPLES
      1      ST LOUIS     SUPE   1          307.2        9983.4          8
>     2      NEMADJI      SUPE   1           86.8         274.0         24
>     3      BOIS BRULE   SUPE   1            9.8          19.5          7
>     4      MONTREAL     SUPE   1           13.7           2.5         12
>     5      BAD          SUPE   1           54.9          49.1         12
>     6      PRESQUE ISLESUPE   2            6.4           0.2         11
>     7      STURGEON     SUPE   2           29.4          71.1         11
>     8      TAHQUAMENON  SUPE   2           24.5           8.4         24
>     9      ONTONAGON    SUPE   2          119.0        1060.5         23
>    10      FORD         MICH   1           10.6           2.4         24
>    11      MENOMINEE    MICH   1          102.6         216.9         12
>    12      PESHTIGO     MICH   1           27.2           8.0          4
>    13      PENSAUKEE    MICH   1            5.3           0.4         12
>    14      OCONTO       MICH   1           42.0          46.2         14
>    15      KEWAUNEE     MICH   1           22.1          55.2         27
>    16      E. TWIN      MICH   1           12.9           1.5         12
>    17      MANITOWOC    MICH   1           86.0         685.9         12
>    18      SHEBOYGAN    MICH   1           93.0         576.3         12
>    19      ROOT         MICH   2           50.3         251.6         12
>    20      FOX          MICH   1          779.9        5948.4         24
>    21      MILWAUKEE    MICH   2           97.4          99.0         12
>    22      ST JOSEPH    MICH   3          296.2        1504.2         12
>    23      KALAMAZOO    MICH   3          200.0         150.6         24
>    24      GRAND        MICH   3          478.9        2891.8         22
>    25      MUSKEGON     MICH   4           33.7          43.0         24
>    26      BOARDMAN     MICH   4            3.4           0.1         12
>    27      WHITEFISH    MICH   4            6.4           2.6         12
>    28      MANISITEE    MICH   4           60.5          81.4         24
>    29      *MANISTIQUE  MICH   4           52.5          26.0         24
>    30      ESCANABA     MICH   4           38.3          49.8         24
>    31      THUNDER BAY  HURO   1           10.8           1.3         12
>    32      AU GRES      HURO   1            7.1           1.3         12
>    33      AU SABLE     HURO   1           22.4           3.6         12
>    34      PINE         HURO   1           72.0        1689.5         12
>    35      RIFLE        HURO   1           15.8          12.0         23
>    36      CHEBOYGAN    HURO   1           30.5         163.2         23
>    37      SAGINAW      HURO   2          602.3        7070.2         35
>    38      GENESEE      ONTA   1          400.0        1414.1         17
>    39      OSWEGO       ONTA   2          752.3        7629.6         20
>    40      BLACK NY     ONTA   3          192.3        2458.6         16
>    41      OSWEGATCHIE  ONTA   3           99.7         311.7          6
>    42      GRASS        ONTA   3           88.9         643.2          4
>    43      RAQUETTE     ONTA   3          109.5         155.8          6
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SOLUBLE ORTHO PHOSPHORUS 1978

		TRIBUTARY NAME	LAKE BASIN	RIVER GROUP	LOAD MT\YR	MEAN SQUARE ERR(MT\YR)**2	NUM OF SAMPLES
	1	BOIS BRULE	SUPE	1	3.5	1.1	7
>	2	NEMADJI	SUPE	1	5.4	0.7	8
>	3	MONTREAL	SUPE	1	6.2	0.2	12
>	4	BAD	SUPE	1	10.6	1.5	12
>	5	TAHQUAMENON	SUPE	2	4.7	1.4	12
>	6	PRESQUE ISLE	SUPE	2	0.6	0.0	11
>	7	STURGEON	SUPE	2	6.2	4.3	11
>	8	ONTONAGAN	SUPE	2	16.4	9.3	11
>	9	FORD	MICH	1	0.5	0.0	12
>	10	MENOMINEE	MICH	1	18.9	25.9	12
>	11	PESHTIGO	MICH	1	31.6	394.0	4
>	12	PENSAUKEE	MICH	1	2.9	0.4	12
>	13	OCONTO	MICH	1	3.1	0.0	13
>	14	KEWAUNEE	MICH	1	11.6	4.2	13
>	15	E. TWIN	MICH	1	5.4	5.7	12
>	16	MANITOWOC	MICH	1	41.3	102.4	12
>	17	SHEBOYGAN	MICH	1	44.0	188.9	12
>	18	ROOT	MICH	2	29.4	115.8	12
>	19	FOX	MICH	1	189.1	1188.7	12
>	20	ST JOSEPH	MICH	3	48.7	139.4	12
>	21	KALAMAZOO	MICH	3	66.9	51.9	12
>	22	GRAND	MICH	3	232.9	568.5	22
>	23	MANISTEE	MICH	4	12.2	3.0	12
>	24	MUSKEGON	MICH	4	11.4	4.1	12
>	25	BOARDMAN	MICH	4	1.5	0.1	12
>	26	*MANISTIQUE	MICH	4	11.0	15.1	12
>	27	WHITEFISH	MICH	4	0.4	0.0	12
>	28	ESCANABA	MICH	4	16.0	41.0	12
>	29	THUNDER BAY	HURO	1	1.8	0.2	12
>	30	RIFLE	HURO	1	2.8	0.2	12
>	31	AU GRES	HURO	1	2.0	0.2	12
>	32	AU SABLE	HURO	1	3.8	0.2	12
>	33	PINE	HURO	1	12.3	5.0	12
>	34	CHEBOYGAN	HURO	1	2.7	0.3	12
>	35	SAGINAW	HURO	2	240.0	859.5	23
>	36	GENESEE	ONTA	1	118.7	752.4	8
>	37	OSWEGO	ONTA	2	243.7	609.3	9
>	38	BLACK NY	ONTA	3	52.3	233.0	6
>	39	OSWEGATCHIE	ONTA	3	18.4	0.3	6
>	40	GRASS	ONTA	3	27.6	104.9	4
>	41	RAQUETTE	ONTA	3	18.2	24.3	6

SUSPENDED SOLIDS 1978

		TRIBUTARY NAME	LAKE BASIN	RIVER GROUP	LOAD MT\YR	MEAN SQUARE ERR(MT\YR)**2	NUM OF SAMPLES
	1	BOIS BRULE	SUPE	1	3858.1	6293354.0	7
>	2	MONTREAL	SUPE	1	873.7	39486.0	12
>	3	OCONTO	SUPE	1	4361.1	3574437.0	9
>	4	BAD	SUPE	1	19835.1	14110186.0	12
>	5	ST LOUIS	SUPE	1	102791.1	404097280.0	8
>	6	NEMADJI	SUPE	1	122145.8	1.0	365
>	7	PRESQUE ISLE	SUPE	2	1510.2	386464.1	11
>	8	STURGEON	SUPE	2	18867.8	75845680.0	11
>	9	TAHQUAMENON	SUPE	2	4367.5	851029.6	22
>	10	ONTONAGON	SUPE	2	119178.6	4508045312.0	19
>	11	MENOMINEE	MICH	1	20842.6	47809648.0	12
>	12	FORD	MICH	1	8840.4	18321872.0	24
>	13	PESHTIGO	MICH	1	5970.7	13177562.0	4
>	14	PENSAUKEE	MICH	1	357.3	19902.6	12
>	15	KEWAUNEE	MICH	1	3543.0	7616410.0	27
>	16	E. TWIN	MICH	1	2521.4	2319370.0	12
>	17	MANITOWOC	MICH	1	13622.2	75933712.0	12
>	18	SHEBOYGAN	MICH	1	18632.5	62755536.0	12
>	19	FOX	MICH	1	170370.8	1519745024.0	23
>	20	ROOT	MICH	2	5481.1	6395605.0	12
>	21	MILWAUKEE	MICH	2	38988.7	457587712.0	12
>	22	ST JOSEPH	MICH	3	71771.6	206378240.0	12
>	23	KALAMAZOO	MICH	3	30821.8	7821415.0	24
>	24	GRAND	MICH	3	62931.4	615050496.0	22
>	25	MUSKEGON	MICH	4	24107.8	101734000.0	24
>	26	MANISITEE	MICH	4	14997.8	2351714.0	24
>	27	*MANISTIQUE	MICH	4	11905.7	2462751.0	23
>	28	ESCANABA	MICH	4	6376.8	3067304.0	23
>	29	BOARDMAN	MICH	4	710.2	44856.0	12
>	30	WHITEFISH	MICH	4	2397.6	651620.2	12
>	31	CHEBOYGAN	HURO	1	3175.1	136764.1	23
>	32	THUNDER BAY	HURO	1	2445.6	232684.2	12
>	33	AU GRES	HURO	1	3761.2	403842.3	12
>	34	AU SABLE	HURO	1	5864.1	530202.6	12
>	35	PINE	HURO	1	81048.3	3366283520.0	12
>	36	RIFLE	HURO	1	13906.1	15346037.0	23
>	37	SAGINAW	HURO	2	148927.7	1682731264.0	35
>	38	GENESEE	ONTA	1	444045.8	5113024512.0	18
>	39	OSWEGO	ONTA	2	160562.6	217462128.0	15
>	40	BLACK NY	ONTA	3	85043.8	1238408704.0	18
>	41	OSWEGATCHIE	ONTA	3	16151.0	1495482.0	6
>	42	GRASS	ONTA	3	2994.3	26227.2	4
>	43	RAQUETTE	ONTA	3	6828.6	627401.6	6

CHLORIDE 1978

		TRIBUTARY NAME	LAKE BASIN	RIVER GROUP	LOAD MT\YR	MEAN SQUARE ERR(MT\YR)**2	NUM OF SAMPLES
	1	ST LOUIS	SUPE	1	25044.5	10710756.0	8
>	2	NEMADJI	SUPE	1	1125.0	31860.7	12
>	3	TAHQUAMENON	SUPE	2	2453.3	273370.9	24
>	4	ONTONAGON	SUPE	2	4075.3	426324.8	23
>	5	PRESQUE ISLE	SUPE	2	606.5	5766.9	11
>	6	STURGEON	SUPE	2	2353.3	372009.9	11
>	7	FORD	MICH	1	1028.0	7504.1	24
>	8	MENOMINEE	MICH	1	7793.5	555200.3	12
>	9	FOX	MICH	1	52688.1	4387524.0	24
>	10	MILWAUKEE	MICH	2	17144.2	37398480.0	12
>	11	ST JOSEPH	MICH	3	73069.6	40175392.0	12
>	12	KALAMAZOO	MICH	3	57381.6	7487332.0	24
>	13	GRAND	MICH	3	115942.4	417755904.0	22
>	14	MUSKEGON	MICH	4	39154.7	1905141.0	24
>	15	MANISITEE	MICH	4	71765.8	11505364.0	24
>	16	*MANISTIQUE	MICH	4	4202.0	176220.2	24
>	17	ESCANABA	MICH	4	7636.0	3358910.0	24
>	18	BOARDMAN	MICH	4	2114.3	1329.6	12
>	19	WHITEFISH	MICH	4	659.9	3988.9	12
>	20	THUNDER BAY	HURO	1	3825.4	142194.7	12
>	21	AU GRES	HURO	1	3959.6	369314.9	12
>	22	AU SABLE	HURO	1	7838.7	27379.3	12
>	23	PINE	HURO	1	689.2	15867.4	12
>	24	RIFLE	HURO	1	5678.2	38973.6	23
>	25	CHEBOYGAN	HURO	1	6821.5	158284.5	24
>	26	SAGINAW	HURO	2	202946.5	1172546560.0	35
>	27	GENESEE	ONTA	1	213370.8	1430424064.0	18
>	28	OSWEGO	ONTA	2	1160764.0	11185729536.0	21
>	29	BLACK NY	ONTA	3	8537.1	2093629.0	15
>	30	OSWEGATCHIE	ONTA	3	5381.8	516396.3	6
>	31	GRASS	ONTA	3	6169.7	6504459.0	4
>	32	RAQUETTE	ONTA	3	4659.8	1260593.0	6

NA - is unknown

APPENDIX D

SUMMARY OF RESULTS

POST-PLUARG MEETING ON POLLUTION ABATEMENT STRATEGIES FOR THE GREAT LAKES

June 24-25, 1980

Great Lakes Basin Commission
Ann Arbor, Michigan

Sponsored by

The Great Lakes Basin Commission
and
The Great Lakes National Program Office, U.S. EPA

MEETING OBJECTIVES

The objectives of the conference were to:

1. reevaluate the Pollution from Land Use Activities Reference Group (PLUARG) findings and recommendations in light of recent developments;
2. consider the International Joint Commission's (IJC) conclusions and recommendations contained in its report to the governments of the U.S. and Canada;
3. identify future research and program needs;

4. reinforce the technical contacts established during the PLUARG study;

5. provide the Great Lakes National Program Office (GLNPO) with information on the progress that has been made toward understanding nonpoint source pollution since PLUARG's final report, and to identify additional information needs.

FORMAT

Participants (see attached list) in the conference included representatives from federal, provincial, and state government agencies as well as representatives from "208" areawide water quality agencies and academic experts from both the U.S. and Canada. The group included representatives from nonpoint pollution control projects and programs underway in the basin as well as a number of the members of the Task C Reference Group of PLUARG. No attempt was made to secure the participation of all of the former members of PLUARG.

The conference focused on providing answers, or at least statements, in reply to a series of questions developed by Great Lakes Basin Commission (GLBC) staff. The questions reflected the PLUARG findings and recommendations, recommendations contained in the IJC's report to the governments, and perceived information needs relating to nonpoint source pollution.

On the first day, a series of eight questions were addressed in plenary session. The following day, attendees were divided into two workgroups to facilitate discussion on a number of additional issues. At the conclusion of the meeting, workgroup moderators presented summaries of their respective sessions and solicited additional comments from the group as a whole. Brief summaries of the discussions and a listing of the major conclusions and recommendations follow.

PLENARY SESSION

QUESTION: The IJC, in its report to the governments, went a step further than PLUARG's final report by recommending regulation of manure-spreading on frozen ground. Do we agree that this recommendation is appropriate? Should it be implemented over the entire basin or just concentrated in dairy areas?

Conclusions/Recommendations

The IJ 's recommendation of manure spreading on frozen ground, as highlighted in its report to the governments on pollution from land runoff, does not reflect the work done on this subject in PLUARG and is not appropriate.

General Discussion

The group concurred with PLUARG's finding that manure-spreading on frozen ground is not a major water quality problem in the basin, although local problems do exist. The press attention the recommendation has received in both the U.S. and Canada has hampered progress in establishing credibility with landowners involved in remedial programs such as the Washington County, Wisconsin, 108(a) Demonstration Project.

While the control or elimination of manure-spreading on frozen ground is appropriate in certain instances, across-the-board mandatory controls are unnecessary. For any given situation, an appropriate mix of controls should be developed which may or may not include elimination of winter-spreading of manure. The most effective nonpoint source controls are those which have been tailored to reflect the local situation.

Government funding of manure storage should not be encouraged because storage is commonly installed for the convenience of the farm operator and should, therefore, remain a part of his cost of operation. Manure storage may cause just as many problems as winter-spreading. Ultimately, the material must be placed somewhere.

QUESTION: Should there be any change in the priority given the problem pollutants in PLUARG's final report? For example, "lead" ... also, "chloride" — cited by some as the most serious long-term problem which could affect the Great Lakes. What new information has become available on the significance of these pollutants?

Conclusions/Recommendations

There is still no indication that lead is causing water quality problems in the Great Lakes. The statement in the IJC's report to the governments that lead is a "pollution time bomb" is unfounded and not in accord with the PLUARG findings. Chloride could have a subtle effect over the long term, but does not pose the imminent hazard certain other toxic substances do (i.e., PCBs).

General Discussion

The switch to unleaded gas should significantly reduce lead pollution in the future.

Urban runoff studies have not highlighted chloride as a nonpoint source problem. Indeed, in some areas of the basin, salt for deicing purposes has become difficult to obtain. This should reduce future use. Large chloride inputs to the lakes may be attributable to point sources.

QUESTION: Are we adequately measuring the lakes' response to nonpoint control measures? Are the percent reductions of P which can be achieved by implementation of various nonpoint source abatement measures, as discussed in the PLUARG report, reasonable?

Conclusions/Recommendations

Continued monitoring is needed to establish whether the load reductions (including available P) expected from different remedial programs actually occur.

General Discussion

We do not have enough nonpoint source controls implemented basin to recognize a whole-lake response to a reduction in loading from this source. However, we are observing marked results in the nearshore areas.

Utilizing sediment as a surrogate for P, Honey Creek study results indicate a 50 to 90% reduction in P relative to the sediment reduction. Study results also indicate that watersheds with fairly low gross erosion rates have a high delivery rate of clays.

QUESTION: How do we evaluate various control programs during high and low runoff events? Do we develop a strategy based on the historical average or do we remove the extreme high flow event from our average?

Conclusions/Recommendations

Event monitoring (including measurement of available P) is needed to determine the effectiveness of nonpoint controls during major storm events. The mechanics of in-lake dispersion of pollutants associated with these events also require further study. In general, control strategies should be based on historical average flows.

General Discussion

The importance of incorporating the catastrophic event in the long-term average is partially dependent upon how success is evaluated. For example, is the concern eliminating instream standard violations or a long-term reduction in pollutant loading to the lakes?

In developing a model, various design flows can be investigated for their impact on the effectiveness of control measures. It was noted that there is not much difference between a 10 year and a 20 year event on urban land. For agricultural land, it is also important to consider the season of the year (i.e., a February storm is of greater significance than an August storm).

It was suggested that strategies be designed by focusing on technical and economical feasibility rather than a storm event.

QUESTION: What form should tributary monitoring in the basin take in the future? Do we need more event sampling? ...sampling to determine available P? What are the findings of significance since PLUARG's final report?

Conclusions/Recommendations

It is recommended that long-term, continuous monitoring programs be initiated on a few key tributaries. Particular emphasis should be placed on storm event samples. This will provide better information than a partial effort on a number of river courses. Little event sampling has been done since PLUARG.

General Discussion

Tributary monitoring is necessary to determine the effects of nonpoint source pollution controls. The costs of monitoring are insignificant when compared to the costs associated with nonpoint source control programs.

Storm event monitoring is presently underway in Wisconsin and Ohio. The Ontario Ministry of Environment has also begun event monitoring at 15 river mouths.

QUESTION: From GLBC staff work, we have found that metal inputs from nonpoint sources are greater than from point sources. Are we agreed that heavy metal inputs still have little effect on the lakes?

Conclusions/Recommendations

There is still no indication that heavy metal inputs are causing water quality problems in the Great Lakes.

QUESTION: "208" agencies have provided much useful information with regard to nonpoint source pollution. What will be the role of "208" agencies beyond 1983?

Conclusions/Recommendations

Ongoing federal and state demonstration projects and programs must be coordinated with "208" activities to assure constistency in the recommendations made to the public concerning nonpoint source pollution control.

General Discussion

A consensus was not reached on what the function of the "208" agencies should be beyond 1983. One view stressed the need for retention of the "208" agencies in their present capacity, recognizing that the planning agencies have established the designated management agencies (DMAs) and could provide them with a regional perspective. Additionally, the "208" agencies have established themselves with local landowners affected by nonpoint source control implementation. Such a working relationship would take a long time to establish and might be difficult to achieve at the state level.

Some participants felt it was time to adopt a more site-specific level of planning (i.e., such as the Wisconsin Fund). The DMAs should fully assume their responsibilities with support from the states and the federal government. Findings from the various demonstration projects, etc., should be implemented through the DMas.

A third view proposed that, in the future, the "208" program should be flexible to accommodate differences among the states. Michigan, for example, has no undesignated areas, while states such as Ohio and Wisconsin have a sizable portion of their area in "non-designated" status. The states already have water quality management planning responsibilities in these areas.

QUESTION: Is it possible to easily identify hydrologically active areas? Have any technological advances been made (i.e., in remote sensing) that would be of assistance?

Conclusions/Recommendations

While the hydrologically active area concept is still valid, it needs further definition if it is to be practically applied. Techniques and guidelines should be developed for identification of hydrologically active areas.

General Discussion

A "common sense" approach is still most widely used in identifying hydrologically active areas in the basin. Slope, soil type, and proximity to the water course are among the parameters utilized for identification. It was noted that the size of hydrologically active areas may vary from year to year, depending on rainfall amount, duration and intensity, as well as other factors.

WORKGROUP I

QUESTION: What are the effects of implementation of no-till practices with regard to: (a) reduction of P; (b) reduction of solids?

Conclusions/Recommendations

Field observations indicate that no-till practices reduce soil loss, thereby reducing both solids and P loading to the streams.

General Discussion

Use of no-till or reduced tillage is increasing rapidly and can be expected to continue. This is largely due to the associated fuel savings and the effort which has been made to demonstrate the utility of the methods to farmers.

Seventy-five to 90% reductions in potential gross erosion have been observed with conservation tillage. Sediment yields have been reduced from 0.5 to 8 tons/acre in some instances.

QUESTION: Are minimum or no-till methods applicable to all parts of the Great Lakes basin, given differences in social and physical factors?

Conclusions/Recommendations

While no-till is not suitable for all parts of the basin, there are a number of minimum-till methods which can be incorporated into a custom-fit program for a particular area.

General Discussion

The time and fuel savings associated with no-till are significant. The economic benefits have sold the practice. Making the equipment available and providing farmers with an opportunity to experience and exchange information on new tillage practices has also been important.

The following reasons were identified as contributing to the negative attitude toward no-till:

(1) prior problems with insects and disease resulting from leaving a cover stand;
(2) misinformation concerning the benefits of no-till;
(3) prior lack of special seed hybrids and herbicides.

Residue management was identified as critical to the success of a tillage system. Seed variety is also particularly important with use of a no-till system.

The incidence of disease and pest problems does not appear greater with use of no-till. Increased usage of pesticides is not necessarily required. Appropriate crop rotations are used. One study has noted an increased incidence of resistant weeds in areas that have been no-till farmed for a number of years.

QUESTION: What new information has become available on costs associated with controlling nonpoint source pollution? For example, is it possible to generalize a cost per some unit of land (i.e., km^2) for a variety of tillage practices?

Conclusions/Recommendations

There is still a lack of detailed cost information for rural nonpoint controls. It is recommended that studies designed to provide detailed cost information on agricultural nonpoint controls be stepped up. Results from studies such as the Nationwide Urban Runoff Program (NURP) should provide information on urban controls in the future.

General Discussion

It is difficult to arrive at general costs for agricultural nonpoint controls because practices are tailored to individual farms. Additional experience with these practices should provide general cost estimates.

To successfully promote conservation tillage you must have: (1) public information and education, (2) financial incentives available, and (3) technical assistance available to the landowner. Of these three requirements, a technical assistance program is, by far, the most important. Financial incentives may be necessary in those areas where conservation tillage has not been previously used (in order to demonstrate the process) and where minimum or no-till cannot be well adapted to site conditions. Other areas may expect to realize an overall economic benefit.

The Nationwide Urban Runoff Program will provide information on the costs of controlling urban nonpoint source pollution. Results from this program should be applicable nationwide. "208" programs have already provided some information on the costs associated with urban controls.

QUESTION: What are some of the possible secondary effects of nonpoint source P and sediment control? For example: (a) greater herbicide and pesticide usage associated with no-till operations; (b) reduced dredging as a result of decreased sedimentation; and (c) decreased particulates in the lakes (which appear to be the major removal mechanism for xenobiotics).

Conclusions/Recommendations

Urban sediment controls reduce maintenance and the manpower hours necessary to clean out municipal systems (i.e., catchment basins).

Conservation tillage and no-till methods increase the soil infiltration rate and, therefore, a larger percentage of the pesticides, nitrates, etc., applied to the land may be reaching the water table. Subsurface drainage may be necessary to protect the groundwater system.

Decreased deposition of sediment in streams could affect fish spawning beds.

QUESTION: How do we evaluate nonpoint source programs when there are numerous objectives (i.e., lake water quality vs. local water quality)?

Conclusions/Recommendations

We presently have insufficient information to properly evaluate nonpoint source programs from a multiobjective viewpoint. Results of the Nationwide Urban Runoff Program should provide us with information on urban controls. There is a need for adequately funded, large-scale, long-term projects which will properly define the impact of rural controls.

QUESTION: What priority should be given to urban vs. rural nonpoint source control in the Great Lakes?

Conclusions/Recommendations

Load reductions should be accomplished by the most cost-effective mix of urban and rural controls. It is impossible to emphasize either rural or urban controls without reference to a specific pollutant.

WORKGROUP II

QUESTION: **What proportion of the soluble P that enters the tributaries (i.e., from point sources) is likely to become part of the unavailable particulate P pool during transport?**

Conclusions/Recommendations

Over the long run, the majority of point source P which reaches the lakes is in a biologically available form. However, a portion of this load remains "functionally unavailable" due to its position in the water column or in sediments.

Studies should be encouraged to determine what percentage of the available P above a point source remains available below the point source input, and what are the primary instream removal mechanisms at different times of the year.

A Great Lakes strategy should address both the nearshore and whole-lake effects of pollution. Future investigations and modeling efforts should reflect this concern.

General Discussion

Highest loading rates of soluble P have been recorded during storm events. However, with high flows the sediment load increases and more adsorption is likely to occur. In contrast, during low flows more P is removed from the stream via biological uptake.

The significance of flood plain deposition to P reduction should not be underestimated. Estimates place this at as much as 50 percent. Deposition may be only temporary, however.

It has been estimated that as much as 80% of the P contributed by point sources is subjected to a temporary sink. Lag time, prior to transport downstream, may vary from a season to a year. Point source P which becomes associated with sediment may still be readily available.

A Canadian study in the Lake Erie basin determined that 20 to 50% of the total P input was associated with sediment (at sediment concentrations of 40 ppm to 180 ppm). This range is lower than that found for most U.S. tributaries. For example, the Black Creek study found 90% of the total P associated with sediment. However, sediment concentrations were notably greater in this instance.

QUESTION: Since a large percentage of the nonpoint P input appears to be unavailable, are nonpoint control programs really worthwhile in terms of P control?

Conclusions/Recommendations

Nonpoint control programs are worthwhile and provide additional benefits beyond reduction of P. These other benefits, such as energy savings and reductions in heavy metal loadings, should be promoted.

General Discussion

It is estimated that soluble P comprises roughly 25% of the total P load to the lakes. Nonpoint sources vary significantly in the proportion of soluble P they contribute.

It is estimated that 25 to 30% of the particulate P delivered to Great Lakes tributaries is available. The available particulate P input is important, however, since the particulate input is often large.

A tendency exists with some to focus solely on sediment management as a means of improving water quality. More information is needed on how remedial programs may affect the loss of soluble pollutants from land.

To reduce the soluble P input from agricultural land, water yield may have to be reduced. Management practices which increase retention and soil infiltration would be encouraged. Proper handling of animal wastes and the correct usage of fertilizers should be promoted to help reduce soluble P loads.

Since large water yields are usually associated with major storm events, the effectiveness of some controls will be curtailed at certain times. Still, during some of these events (convective storms which usually produce long, steady, but relatively low intensity rains) water courses flow slowly and a portion of the soluble P load may be adsorbed.

QUESTION: What new information is available on transmission losses of point and nonpoint source pollutants to the lakes?

Conclusions/Recommendations

PLUARG's conclusion that transmission loss is negligible (a transmission coefficient of "1") over the long run still appears valid.

QUESTION: Do we know the fraction of pollution contained in urban and rural runoff which is attributable to atmospheric deposition on the land? What are the parameters affected by atmospheric deposition? Is this an item that needs to be emphasized in future nonpoint source research, or does enough information already exist for our use?

Conclusions/Recommendations

Although we have estimates of the amount of P attributable to atmospheric deposition in the basin, we lack information on the percentage of pollutants contained in urban and rural runoff which are attributable to atmospheric deposition.

General Discussion

In certain areas of the basin, wind erosion may be a more significant source of nonpoint pollution than generally recognized. Wind erosion which occurs outside the basin may also contribute to Great Lakes pollution.

It appears that clays and organic material are the particles transported long distances. Therefore, the contribution of P from long-range wind erosion may be considerable. "Localized" wind erosion also occurs in which particulate matter may be moved to a position where it is more easily entrained during runoff events.

QUESTION: Should P management strategies be integrated more with strategies for the abatement of toxics and hazardous materials pollution? Are nonpoint source controls likely to have any effect on the input of xenobiotics?

Conclusions/Recommendations

Other advantages of nonpoint source strategies should be recognized -- not only the effects on toxics and hazardous materials pollution but the effects on fisheries, dredging, etc., as well.

While the heavy metals load contributed by rural runoff may be large relative to other sources, this is predominately a natural load. This fact should be noted in future decisions between point and nonpoint pollution strategies.

General Discussion

Pesticide inputs from nonpoint sources deserve additional study. This may become a significant problem in the future as a result of increased use of pesticides in conservation tillage systems.

* * * * * * * * * * * *

The discussion indicated that probably more progress has been made toward understanding nonpoint source pollution problems in the Great Lakes basin than any place else in the world. However, concern was expressed over the fact that, with the completion of PLUARG, no formal mechanism remains for coordination of efforts. A coordinating mechanism is necessary to ensure that results and recommendations from past and continuing programs in both the U.S. and Canada are given publicity; and to ensure that developing programs are oriented toward implementation of both the IJC's and PLUARG's recommendations.

Post-PLUARG Meeting Attendees

John Adams, U.S. COE, Buffalo
James Arnold, Ontario Ministry of Agriculture and Food
Melanie Baise, Great Lakes Basin Commission
Dave Baker, Heidelberg College
Dan Bondy, IJC, Windsor
Dennie Burns, Soil Conservation Service, USDA, Washington, D.C.
Gordon Chesters, University of Wisconsin, Water Resources Center
Ralph Christensen, Great Lakes National Program Office, U.S. EPA
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APPENDIX E

SYNOPSIS OF THE "WATERSHED" PROCESS

The initial step in WATERSHED is division of a river or drainage basin into sub-basin units. Point and nonpoint sources in these sub-basins are then identified and their respective pollutant inputs are estimated. An accounting system is then used to route the inputs downstream to the receiving water as shown in the model schema in Figure 1. This accounting can be performed manually or with the aid of a computer. Transmission losses, which may occur due to a reservoir or other obstruction, are estimated through the application of "transmission coefficients" in various stretches of the tributary. The percent of the pollutant that is likely to reach the receiving water in a biologically available form can also be factored in. Remedial measures can be compared in terms of cost per unit reduction in pollutant input at the receiving water to account for differences between upstream and downstream sources. This basic "accounting system" is readily adaptable to large or small watersheds and can be as general as the user desires.

Techniques for estimating pollutant loads (when these loads are not already monitored) are based on the most accurate and up-to-date information available. For agricultural land, the Universal Soil Loss Equation (USLE) is used in evaluating the effect of various management techniques, such as conservation tillage, on loadings from agricultural land. This allows load reductions to be related to a series of established factors that affect soil erosion losses from land. Widespread use of the USLE in the field has established its validity and utility for this purpose.

The WATERSHED approach can next be used to choose the best mix of point and nonpoint management techniques to achieve a certain load allocation for a receiving water body. Through a cost-effectiveness ranking scheme, WATERSHED shows the order in which remedial measures should be implemented to achieve the greatest water quality improvements at the least cost.

Thus, WATERSHED provides planners and managers with a logical guide to select among point and nonpoint water quality control programs. It will be

most valuable if used with the assistance of individuals or agencies familiar with the specific characteristics of the hydrologic basin under study. WATERSHED's straightforward accounting should be applicable to most river basins, but its application should be customized through the use of local information and expertise whenever possilble.

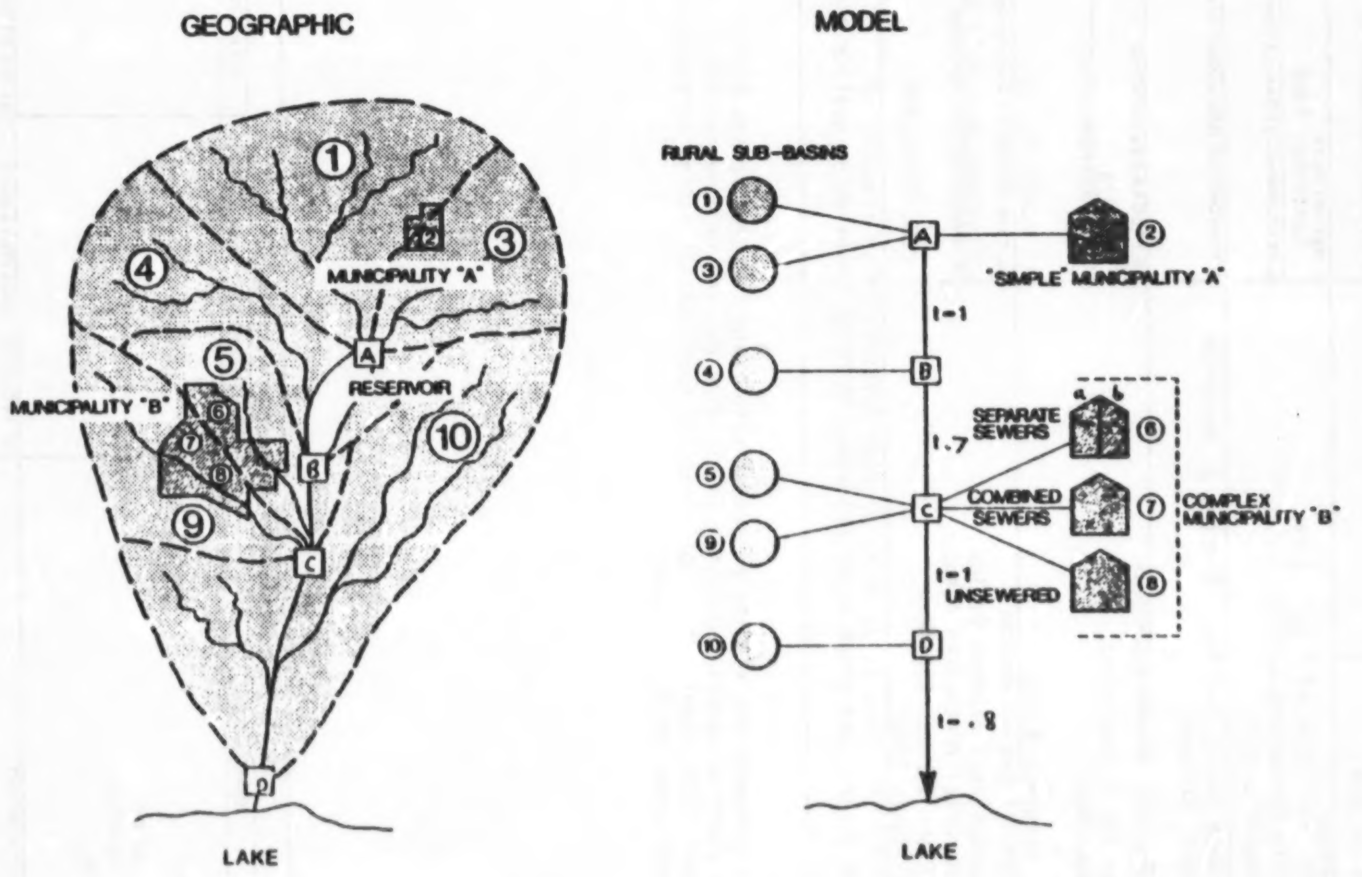
GEOGRAPHIC
MODEL
1
2
3
4
5
6
7
8
9
10
MUNICIPALITY "A"
MUNICIPALITY "B"
RESERVOIR
A
B
C
D
LAKE
RURAL SUB-BASINS
"SIMPLE" MUNICIPALITY "A"
t=1
t=.7
t=1
t=.8
SEPARATE SEWERS
COMBINED SEWERS
UNSEWERED
a
b
COMPLEX MUNICIPALITY "B"
LAKE

FIGURE 1 WATERSHED MODEL ILLUSTRATION

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15. SUPPLEMENTARY NOTES This study is to provide information on a number of significant studies and programs of relevance to Great Lakes water quality problems.

16. ABSTRACT

This report presents the results of recent efforts by the Great Lakes Basin Commission staff to update and integrate the findings and recommendations of the International Joint Commission's Pollution for Land Use Activities Reference Group (PLUARG) with other related studies.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Soil erosion Tillage Non-point source Phosphorus loading Water quality Sediment		

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